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See Advertisement page 49.

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See Advertisement page 28. 6463

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See half-page Advertisement page 90, May 17.

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Services of a Headmaster of a Junior Technical School (to be opened in September) and of Evening Technical Classes. Applicants should be Graduates (or have equivalent qualifications) with previous experience of Technical Education. Commencing salary £300.—Applications should be sent, before June 15th, to the CLERK to the Council, Town Hall, Earlestown, Lancs, from whom further details may be obtained. L 499

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Applications for the following POSITIONS in the Municipal Technical Institute, Belfast:—

LECTURER in PHYSICS and ELECTRICAL ENGINEERING. Commencing salary, £180 per annum, increasing to £200, plus War Bonus of £35.

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Particulars of Duties and Conditions of Appointment, together with Forms of Application, may be obtained from the undersigned, with whom the applications, on the special Form provided for the purpose, must be lodged not later than Noon on Tuesday, 11th June, 1918.

Applications should be accompanied by copies of three recent testimonials (original testimonials must not be sent).

Canvassing will be held to disqualify a Candidate.

FRAS. C. FORTH, Principal,
Municipal Technical Institute, Belfast. L 645

Progress Clerk Required, in Engineering Works. State age, salary and experience. No one already engaged on Government work or resident more than 10 miles away need apply.—Address, L 582, Offices of ENGINEERING.

Clerks, Familiar with Engagement of labour, WANTED for large engineering works in Midlands. Only applicants with experience of engaging labour through Exchanges and possessing initiative considered. No one already on Government work need apply.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 5348. L 590

Office Work in the City, suitable for discharged soldier, for training as estimator; some previous experience useful; facility at figures essential, and able to read and understand drawings.—Address, L 604, Offices of ENGINEERING.

Wanted, Staff Assistant for Electrical Office work in a Government Department at Portsmouth. Applicants to have technical training and experience in the design of of electrical apparatus. Salary £260 per year.—Replies to BOX 1520, WILLING'S, 125, Strand, London, W.C. 2. L 597

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Wanted, Two Good Capable ELECTRICIANS, must have had experience of bells, telephones, and lighting. Plant supervision essential.—Apply, stating age, references, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5309. No person already employed on Government work will be engaged. L 464

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF THE NAVY.

Assistant Inspector Required, with good practical knowledge of Marine and Mechanical Engineering and Boiler Making. Electrical experience also preferred. Must be capable draughtsman.—Apply, stating salary required and giving particulars of previous experience, to the NAVAL REPRESENTATIVE, Australia House, Strand, W.C. 2. L 606

Assistant Works Manager.—REQUIRED, a capable Engineer conversant with Internal Combustion Engines. State age, salary and experience. Permanency. No one already engaged on Government work or resident more than 10 miles away need apply.—Address, L 580, Offices of ENGINEERING.

First-class Viewer, used to testing Gears for High-class Motor Works. State wages required and full particulars of experience. No person already on Government work will be engaged.—Apply to the nearest EMPLOYMENT EXCHANGE, mentioning No. A 5291. L 634

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A/S. CHRISTIANIA STAALVERK.

For construction of a new 50,000 tons Rolling Mill WANTS a First-class

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Applications requested to the direction of
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Wanted, Chemist, Preferably with metallurgical knowledge, to work on the production of non-rusting steels and allied subjects, at works situated in Birmingham.—Address, with a statement of training, experience and salary required, L 650, Offices of ENGINEERING.

Chemist, Steelmaking, WANTED. Stock converter plant and Heroult furnace. No person already on Government work will be engaged.—Apply, giving age, experience, salary required, references and date when free to commence duties, to your nearest EMPLOYMENT EXCHANGE quoting No. A 5227. L 647

Engineer (Works) Wanted. To be responsible, under Chief Engineer, for the running, upkeep and erection of large factory plant, including Boilers, Turbo Generators, large Gas Engines, Diesel Engines, &c. Must have had thoroughly technical and practical training and have held a similar position. Previous experience in a chemical factory an advantage. State fullest particulars, with copies of testimonials and salary required. (See War Notice.)—Address, L 528, Offices of ENGINEERING.

Assistant Water Engineer WANTED, for the Burgh of Greenock. Applications, stating experience and salary required and accompanied by testimonials, to be lodged with the WATER ENGINEER, Municipal Buildings. See War Notice. L 599

Shift Engineer Wanted to take charge of 12-hour shift. Must have good experience with Lancashire boilers, turbo alternators, and three-phase supply. No one on Government work eligible. Useless to apply unless keen disciplinarian. Good wages, Sunday time extra, and bonus.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 5334. L 591

Wanted, Competent Man for supervision of production at 8 in. Projectile Factory. Must be energetic, tactful, and experienced in handling female labour. Good salary. Anyone at present employed on Government work need not apply.—Apply, stating age, experience, and reference to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 5363. L 589

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State full experience, age and salary required. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5339. L 615

Representative Wanted on LONDON STAFF by one of the larger Sheffield firms of Steel, File and Tool Manufacturers. Should have thorough knowledge of the trade and good connection.—Apply, giving full particulars of experience and salary required to "REPRESENTATIVE," care of Messrs. T. G. SHUTTLEWORTH & SON, Chartered Accountants, Church Street, Sheffield, who will supply, in confidence, any information required. Applicants must be ineligible for general military service. L 641

Head Salesman Required, by Engineers' Merchants, must have full knowledge of Export and Shipping trade and competent to prepare and establish Agencies Overseas for Engineers' Goods. State age, experience and salary required. No one already engaged on Government work or resident more than 10 miles away need apply.—Address, L 583, Offices of ENGINEERING.

Machine-Tool Assistant REQUIRED for London district. Experienced in purchase and sale of modern machine tools. Ineligible. No one already employed on Government work, or resident more than 10 miles away, will be engaged. State age, experience and salary.—Address, L 642, Offices of ENGINEERING.

Urgently Wanted, One Jig and TOOL INSPECTOR for Tool Room, used to accurate work. No person engaged on Government work will be engaged.—Apply, A 5367, nearest EMPLOYMENT EXCHANGE. L 596

Wanted, Immediately, for Midland firm engaged on Aero Engine work, first-class Jig and Tool INSPECTORS. State full particulars of experience. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5300. L 637

Wanted, Immediately, for Midland firm engaged on Aero Engine work, first-class INSPECTORS for View Room. State full particulars of experience. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5197. L 633

A Vacancy Occurs in the Birmingham district, for work of National importance, for a well qualified Mechanical ENGINEER possessing tact, energy and discretion. Must be ineligible Military service. Commencing salary £260.—Address, L 618, Offices of ENGINEERING.

Machine Tool Draughtsman REQUIRED for special tools. Good opportunity for a really smart man. Controlled factory. Reply, stating qualifications and salary. No one already on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5327. L 475

Draughtsmen (Electrical) WANTED for the Midlands; preference given to men with experience in the design of D.C. and A.C. Machines or Transformers.—Apply, stating age, experience and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A. 4898. Nobody engaged on Government work will be engaged. L 474

Tool and Plant Draughtsmen REQUIRED for urgent aero and motor work in progressive Midland works. Permanencies for live interested quick men with initiative and ability. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE mentioning No. A 5316. L 477

Draughtsmen Required in important munition works. These accustomed to furnace design preferred. No one on Government work or living more than 10 miles away will be engaged. State experience, age, and salary required.—Apply, BOX 134, Advertising Offices, 84, Queen Victoria St., London, E.C. 4. L 551

Draughtsman Required, with good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4694. K 393

Draughtsmen.—Wanted Two Plant Lay-out DRAUGHTSMEN, must be used to laying out plant, not particularly specialized in detailing. Applications from those with knowledge of building construction will be considered. No one already on Government work will be engaged.—Apply, with full details of experience, salary required, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5360. L 598

Two Centrifugal Pump DRAUGHTSMEN WANTED; some experience essential. Age over 30, good prospects. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5383. L 614

Capable Draughtsman Wanted for Machine Tools by firm of Engineers in the London district. No person already engaged on Government work or resident more than 10 miles away will be engaged.—Apply, stating experience and salary, to L 617, Offices of ENGINEERING.

Draughtsmen.—Two Wanted, by Munition Works on Tyneside, with experience in design of Jigs, Tools and Works Plant. No person already engaged on Government work need apply.—Reply, stating age, experience and wages required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 621.

Wanted, a Draughtsman, preferably with experience of water purification plant; no one already on Government work need apply.—Write with full particulars of experience, etc., and salary required to L 572, Offices of ENGINEERING.

Chief Draughtsman Wanted for Controlled Establishment in West Riding of Yorkshire, manufacturing Petrol-Driven Commercial Motor Vehicles. Only those having previous first-class experience need apply, and no person already on Government work will be engaged.—Apply in first instance to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5341, and stating particulars of experience, age and salary expected. L 574

Wanted, for Urgent Government work, South-West London district, JIG and TOOL DRAUGHTSMEN, accustomed to high-class, small, and accurate work.
No person already on Government work will be engaged.
Apply by letter, stating age, experience, and wages required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5357. L 576

Draughtsmen.—Several Good Constructional DRAUGHTSMEN required to work on details of fabricated ships and other structural work. No one already employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5358. L 579

Draughtsman Required Immediately, thoroughly experienced in Semi-Diesel Oil Engines, land and marine. Good salary will be paid to suitable man. No person already on Government work will be engaged.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5300. L 584

Draughtsmen for Aeronautical work REQUIRED immediately for Midlands, previous knowledge desirable, but not essential. No one on Government work eligible.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 5335. L 592

Draughtsman Required for Midlands. Must have had thorough training and experience in designing machine tools. Good scope for improvement to energetic man with initiative. No one already employed on Government work will be engaged.—Apply, stating full particulars of experience, salary required, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 481.

Capable Draughtsman for Machine Tools WANTED by Controlled firm of engineers in Manchester. No one already on Government work or resident more than 10 miles away will be engaged.—Apply, giving all usual particulars, through your local EMPLOYMENT EXCHANGE, quoting this Journal and L 530.

Reinforced Concrete Work.—DRAUGHTSMAN or Smart JUNIOR REQUIRED by Controlled Firm in Manchester, must be quick at making up Drawings and Specifications. No one already employed on Government work will be engaged.—Apply, stating age, full experience and salary required, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 504.

Wanted, First-class Mechanical and Structural DRAUGHTSMAN, also JUNIOR for Government controlled office in Manchester. One experienced in crane work preferred, but not essential. No one already employed on Government work will be engaged.—Apply, stating age, full details of experience and salary required, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 503.

Wanted, Sheerness District, good Civil Engineering DRAUGHTSMAN, experienced in surveying and general building construction; ineligible for Military Service; salary about £240 per annum.—Apply, stating age, full particulars of experience, and enclosing copies of recent testimonials, to BOX 1519, WILLING'S, 125, Strand, London, W.C. 2. L 586

Wanted, Experienced Jig and TOOL DESIGNERS for large Electrical Works in the Midlands. Knowledge of Press Tools an advantage. Good salary and permanency to really capable men.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 4880. Nobody already employed on Government work will be engaged. L 496

Tool and Plant Draughtsmen REQUIRED for urgent Aero and Motor work in progressive Midland works. Permanencies for live interested quick men with initiative and ability. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5316. L 636

Draughtsman Wanted, by Firm of Gas Engineers and Contractors. Must be accustomed to gas plant and structural work, capable and energetic. No application from persons already employed on Government work will be considered. Full particulars of experience, age, and salary to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5394. L 639

Good Detail Draughtsman REQUIRED in steam excavator department. One with steam crane or good general experience preferred. Good opening for a suitable applicant. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5387 and this Journal. L 638

Draughtsmen Required by an Admiralty Department:—
(a) Those with good general mechanical engineering experience.
(b) With good general electrical experience.
In both cases must be capable of preparing full working drawings from rough designs and sketches.—Apply, giving full details of training and experience, age, salary required and when at liberty, to BOX 1539, WILLING'S, 125, Strand, W.C. 2. L 626

Draughtsman Required to TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 624, Offices of ENGINEERING.

Draughtsman Required for constructional engineering works (Government controlled) in Birmingham district.—State age, salary and full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 471. No one on Government work will be engaged.

Leading Draughtsman Wanted Manchester District. Government Contracts. Thorough experience furnace work essential, experience structural work an advantage.—Address, stating age, experience, and salary required, L 573, Offices of ENGINEERING.

Senior and Junior DraughtsMEN REQUIRED, accustomed to the Design of Electrical Machinery. No one engaged on Government work or residing more than 10 miles away need apply.—State age, training, and experience and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 443.

Assistant and Junior DRAUGHTSMAN. Required in Hydrant Section, London Fire Brigade, an Assistant with knowledge of engineering or contractor's accounts, and also a Junior Draughtsman. Wages £2 to £3 a week each, according to qualifications. Candidates must be ineligible for Military service.—Apply to CHIEF OFFICER, London Fire Brigade Headquarters, Southwark Bridge Road, S.E. 1. L 554

Draughtsmen (12), Jig and TOOL, urgently REQUIRED. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5318. L 561

Required for Temporary Service in Government Department, DRAUGHTSMEN with knowledge of textile machinery. Applicants, who must be ineligible for Military Service, should reply, stating age, qualifications, experience, &c., to BOX 329, care of J. G. KING & SON, 10, Bolt Court, Fleet Street, London, E.C. 4. L 644

Draughtsman Required for LONDON, on work of National importance. One with experience in Flour and Starch Mill planning preferred. Liberal salary, exceptional prospects offered to efficient and capable man.—Write, giving details of previous experience, to "FLOUR," care of FROST SMITH & Co., 66, Finsbury Pavement, E.C. 2. L 649

PAYMENT BY RESULTS: A PSYCHOLOGICAL FACTOR IN WORKSHOP EFFICIENCY.

By ALEX. RAMSAY.

ONE of our constant and pressing problems is that of maintaining and increasing the productive efficiency of our factories. The more efficient a plant, the greater the volume and the cheaper the cost of product; and consequent upon these conditions the stronger the possibility of securing a satisfactory hold upon competitive and keenly-cut markets. We are therefore dominated by ambitions to achieve repetition method; to apply jig, tool and fixture to the possible limit; to perfect shop routine and attain a grand marshalling of component parts to simultaneous completion; to eliminate frills, to cut waste, to speed up. We live in an atmosphere of feeds, speeds, and cutting compounds; we regard system and organised method as essentials. The war has taught us many lessons in the science of production, and as a result, mechanical efficiency is no longer a scientific speculation, but has become a definite and ruling *motif*.

If our problem ended with the control of mechanical agencies we should have some ground for feeling that quite satisfactory progress was being made towards a solution, but unfortunately the mechanical is largely dependent for result upon the human, and it is not untrue to say that from this point of view our study has been superficial, our attitude prejudiced by mistaken conceptions of the direction in which lay our personal interests, and our efficiency as producers seriously limited through our inability to understand and control a vital factor in the manufacturing equation. We are in a condition of industrial ill-health, and shall so remain as long as the workers who constitute the channel through which flows our volume of output, restrict their production to an extent greatly below that of which they are easily capable. "Limitation of output" is not a stock phrase for a passing symptom; it describes an almost universal disease that is destroying our economic vitality.

Self-interest is a governing passion with workmen as with employers, and the surest way in which to encourage a man's best exertion is to definitely associate his earnings with the amount of work he performs. There are few present day workers who have a loyalty to their employers sufficient to cause them to take a real and personal interest in the prosperity of their factory. They are paid for the time they serve, and not unnaturally their main anxiety is with regard to the passage of time. But pay them according to the amount of work they produce, and the volume of output at once becomes a matter of personal concern.

There are three such systems of payment commonly in operation:—

(*a*) The premium bonus system.

(*b*) A system by which a bonus is paid varying with the total output of a shop or factory, and to all employees, without particular relation to the individual amount of work produced.

(*c*) The system of "straight" piece-work.

In the writer's experience the great demerit of the premium system lies in the fact that the majority of men remunerated under it do not understand the exact effect of its application, and consequently regard it with grave suspicion. They feel, rightly or wrongly, that the division of time saved, operates to their advantage only to a point beyond which no substantial inducement exists for them to accelerate output. The unofficial attitude of official trades unionism is distinctly hostile to the scheme, and the psychological effect of such an atmosphere greatly mitigates against its efficient operation. Indeed, so determined is the opposition from this quarter that in certain instances recently it has been found quite impossible to introduce it. The system specially appeals to those who are not too confident of the ability of their rate-fixing department, or who feel that their workpeople should not in practice be remunerated beyond a certain additional proportion of their time rate of wages, but such a policy, when consciously adopted, is extremely short-sighted, and involves a financial loss to the employer greater than that inflicted upon the worker.

There are certain classes of occupation in which the second indicated method of computing an output bonus is the only one possible. In the cases, for example, of foremen and charge hands whose separate activities can not be definitely assessed on a time or money basis, the result of their efforts can only be gauged by the total output of the sections or departments which they control. Much depends for efficiency upon the energy and capacity for foresight displayed by supervisors, and although their status is higher than that of the workman, their outlook on questions of personal profit is much the same. It has been proved beyond question that the stimulating influence of an output bonus is enormous, and those who have adapted this method are not likely to revert to the practice of payment by fixed salary. In computing a bonus the volume of output is not the only factor which should be taken into consideration, because output can on occasion be increased by excessive overtime and other wasteful expedients which raise the cost and operate to the disadvantage of the employer. On the other hand, it is essential that the basis of calculation should be simple and clearly understood, because a system which is not understood by those participating in it, has a moral effect exactly equal to the reputed honesty of the management. Undernoted is a formula which in theory is probably open to criticism, but which in actual practice works extremely well.

$$\frac{\text{Value of shop output at cost}}{\text{Total cost of shop wages}} \times X \text{ Percentage of time wage to be paid as additional bonus.}$$

In the first place it should be noted that in most concerns the value of output is periodically ascertained as a matter of ordinary factory routine, so that no extra labour is here involved. This value naturally varies with the cost of material and other factors over which the foreman has obviously no control, but curiously enough it has been found that while the cost of material fluctuates, the cost of labour also changes, and the balance of the equation is not seriously disturbed. X is a factor which must be in each case determined and will vary with the proportion of a man's total remuneration it is proposed to pay in the form of bonus; but when the factor X has once been established, it is naturally maintained as a constant and the result fluctuates according to the value of output and the cost of labour. For example, we decide that the total remuneration of foremen is to be made by fixed salary plus a bonus which we determine should be on a basis of 30 per cent. of the same. Let us assume that value of output to cost of wages is in the proportion of 3 to 1, we find that

$$\frac{3}{1} \times X \text{ equals } 30 \text{ per cent.}$$

$$\therefore X \text{ equals } 10.$$

Nothing is claimed for this scheme except the fact that in actual operation it has proved very successful.

The system of paying a bonus according to shop output is not recommended in the case of manual workers because there are few classes of labour who cannot be paid by the method of direct piece-work if the problem is seriously tackled. Particulars could be given—did space permit—of systems in operation applied to inspectors, setters-up and barrow labourers, occupations which by reason of the diversity of activity, offer the most difficulty of any. In the case of a workman, the stimulus of a bonus is completely lost unless he sees a direct connection between his individual effort and his pay bag. He is the last person in the world to take his fellow-workman on trust, and he is quite sure that he is not going to earn a bonus for someone else to enjoy. It may be stated as a sound general principle that the man who knows that he will be paid for exactly what he does—no more and no less—is the man from whom the greatest effort may be expected.

For this reason, remuneration under a system of "straight" piece-work is, in principle, the most encouraging and efficient method. The necessity for a caveat will become apparent. A contract is made with a workman to perform a specific piece of work for a certain sum, and he is supposed to let himself go and earn as much as he can. Under such conditions one would be inclined to expect the maximum output, but human nature is a complex quantity, and as a matter of actual fact, one's theoretical anticipations are far from being realised. What happens is something like this. A price is under discussion and the worker looks upon it as a holy mission to screw out of the employer the best figure he can. Backed by the moral influence of his shopmates who are also professionally interested in the game of besting the ratefixer, he frequently exacts a price which is generally recognised as unfairly and unnecessarily high. But he knows, too, from experience, that if he earns more money than the general sense of the shop considers adequate, the employer will undoubtedly find some expedient for reducing the price to a more reasonable level, and so in spite of the fact that he could easily produce more, he restricts his output and his earnings with the result that the more generous the piece-work price, the less work is frequently performed. A picture of considerable gravity could be drawn of the disaster which is likely to result to British industry through the practice of limiting output, and we shall do well to consider what steps may be taken to remove a growth that is throttling our economic activities.

We must begin with fundamentals, and the genesis of the evil lies in the fact that no serious attempt has been made to advance beyond a theoretical stage the economic truth that the ultimate interests of Capital and Labour synchronise and are bound up with one another. Capital is a producer of wealth because it is the means by which is made possible the operations of Labour; and Labour is a wealth producer because it is the primary agency through which the function of Capital is productively exercised. There is, therefore, a scientific basis for agreement between the two, and no reason, save that of a doubtfully conceived personal advantage, for difference.

Now a piece-work contract, to have any moral justification, must fulfil two conditions, namely, that it should be a fair contract and made without any mental reservation regarding its subsequent violation. As previously indicated, many contracts are now fixed which are unfair to the employer. Let us consider a concrete case which illustrates the difficulty of price negotiation. Two men, A and B, were operating the same machine on the same job, one on day shift and the other on night. For the job in question the ratefixer estimated that 7*s.* 6*d.* was a fair price, but the men asked 15*s.* 6*d.* As usually happens in cases of acute difference, they were required to perform the job on a day-work or time basis, with the result that the machine efficiency immediately dropped to 30 per cent. of the possible. What action is possible to the employer in such circumstances? To dismiss a man because of a dispute over piece-work prices would involve a general stoppage, and no other worker will perform the operation at a figure less than that which his fellow-workman demands. A ultimately compromised, and accepted 9*s.* 6*d.*, making in the first week, on a repetition job, a bonus of 100 per cent. in advance of his time rate. B remained obdurate and inefficient, until by diplomatic manipulation he was finally removed to another machine.

Disputes of this nature obviously should not arise, because the price which ought to be paid for a specific piece of work is a matter, not of opinion, but of fact. The facts are demonstrable, but unfortunately no machinery possessing the confidence of the men has existed to establish them. The writer in his book on "Terms of Industrial Peace" suggested that the workers appoint one of their number to act in conjunction with the ratefixer and fix all prices, such prices, calculable and provable, being accepted by him on behalf of the men and enforced by the authority of the trades unions. That such a scheme may not be lightly turned aside or thoughtlessly condemned as unpractical, there are subjoined the terms of a definite agreement since entered into between an Association of Engineering Employers and a Federation of the craft unions of an industrial area:

"In the fixing of piecework prices, should the employer's representative and the workman be unable to agree, the matter shall be referred to a

committee composed of three workmen from the same department and engaged on similar work, and such representatives as the management may select, *who shall fix the price of the job in dispute.*"

It is considered by men and employers alike that the terms of this agreement will materially tend to remove the possibility of prices being unfairly fixed, and so overcome the restrictive influences which are inherently associated with such a dishonest practice. But another vital condition is essentially implied in these provisions. A price having been fairly established should not be broken unless the method of production be improved or greater facility be given to the worker to perform the operation which is the substance of the contract. Some employers regard it as a personal loss if their workmen earn more than a certain sum weekly, and knowing this fact, the workmen are generally careful to ensure that this figure is not exceeded. Prices are usually calculated on such a basis as will permit the average worker to earn a recognised bonus in addition to his time wages, but if a man, by more than average energy or by exceptional ability, earns a bonus in excess of the generally accepted standard, the increase of wages resulting from an increased output, is not a loss, but is clearly to the advantage of the employer. If a man is expected to produce 100 articles per week at 1*s.* each, and actually produces 150, the extra 50 do not cost the employer more, but, on the contrary, place him in possession of the presumed profit and materially reduce his establishment charges on the work in question. Let us consider a concrete case and see how the argument develops. Two semi-skilled men, A and B, are rated at 8*d.* per hour and engaged upon a job, the piece-work price for which is 5*l.* It is estimated that the price will enable the men to earn 1*s.* per hour.

	A.	B.
Time taken... ...	100 hours	70 hours
	£ *s.* *d.*	£ *s.* *d.*
Piece-work price ...	5 0 0	5 0 0
Time wages ...	3 6 8	2 6 8
Bonus to worker ...	1 13 4	2 13 4

Cost to Employer.

	A.	B.
	£ *s.* *d.*	£ *s.* *d.*
Piece-work price ...	5 0 0	5 0 0
Establishment charges at 2*s.* per hour	10 0 0	7 0 0
Extra allowance for depreciation, repairs and power required	Nil	1 10 0
Total cost ...	15 0 0	13 10 0

It will be seen that B earned 1*l.* more than A, and the employer actually saved 1*l.* 10*s.* because of the fact. But he not only saved, he gained, for he was left in hand with 30 hours' productivity of a valuable machine.

In the agreement previously mentioned, the maintenance of a price once fairly fixed is assured by the following provisions:—

(*a*) All prices shall be given in writing and on the understanding that a price once fixed will not be reduced unless increased facilities for production are given, or unless the job itself is altered, in which case the price may be the subject of reconsideration.

(*b*) As a protection against obvious mistakes in the fixing of prices, it is further agreed that prices which have been mutually arranged, may, on application of either party, be brought forward at any time for reconsideration.

The case for such working arrangements as those just indicated is unanswerable, and Labour, if properly handled, will not be found obdurate. Probably the only objection will come from those who cling to the pitiful conception that agreements made with Labour regarding internal administration are likely to undermine the prestige and standing of the employer, and improve the economic prospect of Labour at the expense of Capital. For a generation we have bewailed the fact that our workshops were only 50 per cent. labour-efficient, but it would be much more in keeping with the constructive genius of the industrial world if we took some steps to ensure that the conditions giving rise to such a situation were understood and removed. The days have long since passed when the presence of a foreman was sufficient to effect the maximum labour output. A workman is not now an isolated unit who may be coerced; he is a part of an organisation of power and influence, which refuses to be driven, but which is willing to bargain. Let us therefore consider and evolve our terms and make some worthy attempt to put upon a new foundation the structure of our personal relations, and so end a state of affairs which sacrifices profit to dignity, and enhanced prosperity to the maintenance of a sham authority. Labour continues to be insistent upon better terms of remuneration and conditions of employment, and in spite of the fact that many of the existing standards of value have been artificially created, there is little possibility of employers being able to readjust the economic balance to a pre-war setting; because the insistence of the workers is backed by a very real power of enforcement. That being so, it is surely clear that the constructive minds of industry should explore the opportunity of meeting the increased cost of labour by improving the productivity of the factory, a combination which can best be achieved by exploiting the system of payment by result, and cutting from it the evil appendages which now restrict its scope and effectiveness.

THE NEW TROLLHÄTTA CANAL.

THE new Trollhätta canal was opened with much ceremony by the King of Sweden on October 25, 1916. This occasion marked a new and important phase in the history of this famous canal, and afforded another proof of the foresight and energy with which the Swedish authorities and Legislature are furthering measures in the interest of the national industry and commerce. The new canal, or the new extension of the old canal, is the outcome of a Parliamentary vote of May, 1909, when 22,800,000 kroner (1,270,000*l.*) were granted for the purpose, the work being placed under the then newly appointed Royal Waterfalls Board. Many years ago King Gustaf Vasa, that true father of his country, took steps to create a navigable waterway from Lake Vänern to Trollhättan. His three sons, all kings in succession, continued the work, and the first lock, at Lilla Edet, was opened, probably in 1607, and extended in 1610. Charles XII, the warrior king also took a keen interest in this waterway at the instance of Emanuel Swedenborg. Polhem, whose name is so closely linked to that of the Trollhätta canal, prepared several plans, the first being completed in 1717 and the last 30 years later. The work was commenced, but it was not until two of Polhem's pupils had further developed the plans that the first navigable waterway along the Göta river was completely designed. The work was started, but the Swedish exchequer had many other calls upon it, and in 1779 it came to a standstill. In 1793 a private company was formed for the purpose of realising the scheme, and within seven years the work was completed. On August 14, 1800, the first vessel passed all the locks, thereby establishing direct connection from Lake Vänern to Gothenburg. By degrees further extensions became necessary, and in the year 1835 Major Nils Ericson, a famous engineer, prepared plans for them. On May 16, 1841, the extended waterway was opened. At the end of last century fresh extensions became necessary; various plans were discussed, the one which has now been adopted being the work of a commission appointed for the purpose.

The new canal has been constructed to accommodate vessels of 4 m. (13 ft. 1½ in.) draught; the locks, however, have been built to pass vessels of 5 m. (16 ft. 5 in.) draught, as have the bridges, and some portions of the waterway, where future deepening and widening could only be undertaken at a great cost. A bottom breadth of 24 m. (79 ft.) has been adopted as a minimum; this breadth does not allow of the largest vessels passing each other, but serves as a double waterway for vessels 9 m. (29 ft. 6 in.) beam, which has been considered sufficient in the meantime. Passing places for larger vessels have been provided in sufficient numbers. The following table contains additional particulars:—

	Greatest Navigable Depth.	
	4 m.	5 m.
Breadth of bottom in the artificial canal	m. 24	m. 24
Breadth of bottom in the artificial canal at passing places... ...	29	35
Breadth of bottom in river or lake	40	48
Minimum depth of water in rock cutting	4.4	5.5
Minimum depth in dug canal, with firm bottom	4.4	5.5
Minimum depth in dug canal, with loose bottom	4.8	6.0
Minimum depth in river or lake...	4.8	6.0
Highest permissible speed:	knots.	knots.
In river or lake	8	9
In canal (for largest vessels) ...	3	3
Smallest radius of curve at entrance to lock	m. 500	m. 500
Smallest radius of curve in other parts	500	600
Minimum depth of water at lock sill	—	5.5
Breadth at lock gate opening ...	—	13.7
Length of lock chamber	—	90.0
Length of lock from gate to gate	—	97.9

The length of the new waterway is about 84 km. (52 miles); from below the Bommen it follows principally the Göta river (Fig. 1, page 597), and runs along the actual river bed over a distance of about 75 km. (46·6 miles). As shown in the longitudinal profile (Fig. 2), the difference in level between Lake Vänern and the Kattegat, at ordinary water-level, is 44.35 m. (146 ft.). There are several falls in the river, which impede navigation; on the section Källshagan-Vargön the height of fall amounts to 5.7 m. (19 ft.), at Trollhättan, before the reconstruction, to 32.6 m. (107 ft.), at Akerström, before reconstruction, 1.0 m., and at Lilla Edet, before reconstruction, 3.5 m. (11½ ft.). The remaining difference in level has been fairly evenly divided over the sections between the above-mentioned falls. Typical cross-sections of the canal are reproduced in Figs. 4 to 9, page 597. The method of protecting the banks by stone pitching is illustrated in Fig. 10.

Formerly the Källshagan-Vargön fall was passed by means of two locks. The new waterway partly follows the old one, but past the town of Vänersborg (Fig. 1) a new canal has been constructed, and the fall has been passed by means of one lock, located about half-way between the two old ones. From Bommen to Trollhättan, 7.0 km. (4.35 miles), the waterway follows the river except over a distance of 1.3 km. (1,420 yards) past Stallbacka, where the river is very broad and shallow. An artificial canal had previously been constructed along this portion of the river, and this old canal was followed in building the new waterway, but the low-water level of the river above Trollhättan has been raised some 40 cm. (16 in.) by damming, so as to obtain sufficient depth without entailing too much expenditure.

The traffic was formerly taken past the Trollhättan Falls by means of a canal, some 2 km. (1¼ miles) long, ending in a small lake named Akerssjö; from this two systems of locks, that of 1844, with 11 locks, and that of 1800, with 8 locks, led back to the river. The new waterway follows in the main the old one to Akerssjö, which has been widened, deepened, &c., but a new canal has been constructed for part of the distance, so as to obtain a straighter course. From the lake four locks lead down to the river, the two bottom ones being contiguous. From below Trollhättan to Lilla Edet the profile of the river has been altered by a dam at Lilla Edet (Fig. 3), which holds up the water to such a level that the fall at Akersström, and part of the fall at Trollhättan below the power station, are obliterated and the fall at Lilla Edet is increased. By this alteration the river has become navigable the whole distance from Trollhättan to Lilla Edet. These alterations raise the fall at Lilla Edet to 5.45 m. (18 ft.), instead of the former 3.5 m. (11½ ft.). Formerly there were two locks, whilst now there is only one, placed close to the upper of the old locks. The canal past Lilla Edet has an aggregate length of 1 kilometre (3,280 ft.). Below Lilla Edet the waterway follows the river, the course having been straightened and deepened (Fig. 1).

The work on the new waterway was divided into eight sections; most of the work was carried out by direct labour, but some masonry and dredging

THE NEW TROLLHÄTTA CANAL; DETAILS OF

(For Description, see Pag

Fig.21. DOWN STREAM VIEW.

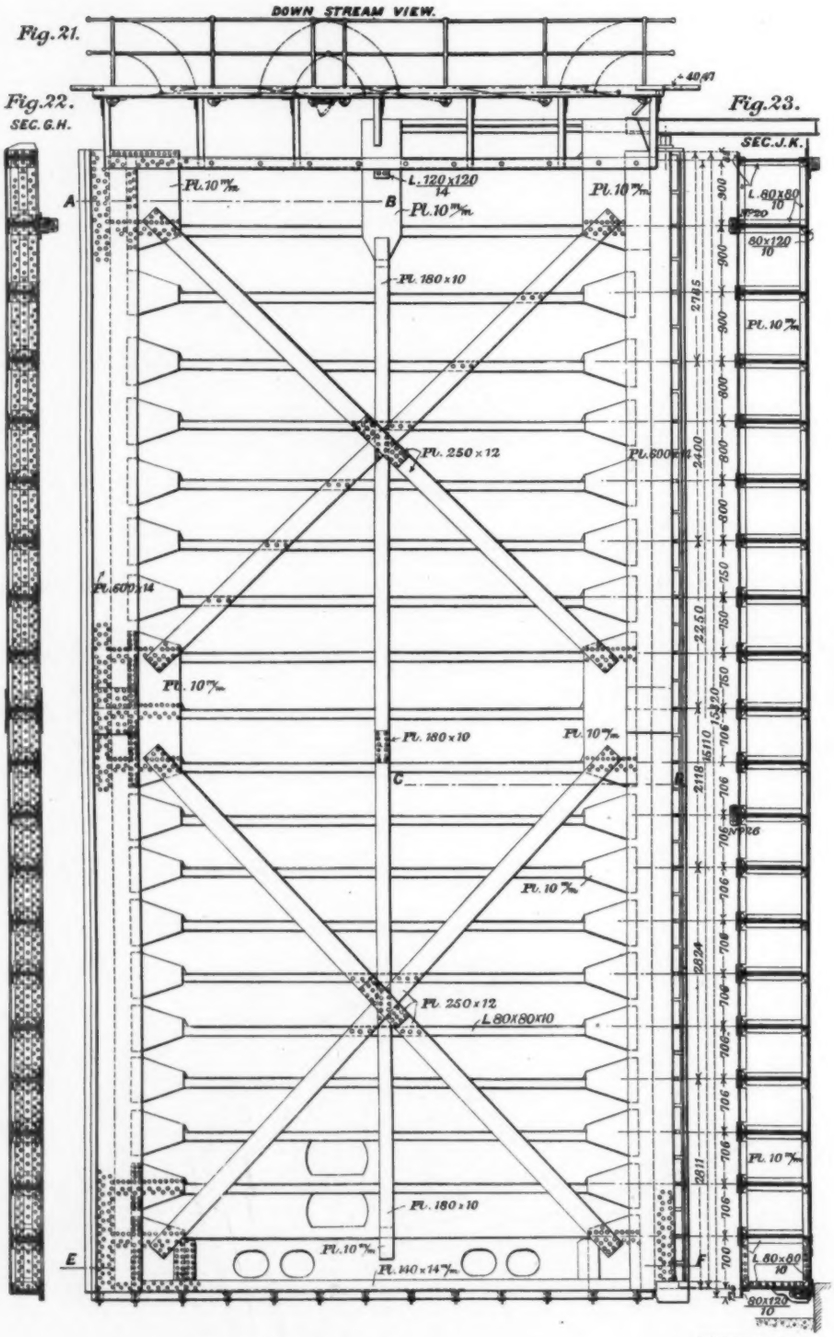


Fig.24. SECTION A B C D.

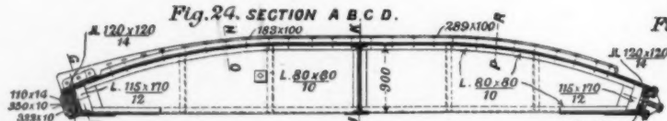
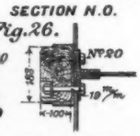


Fig.25. SECTION E.F.

SECTION N.O.
Fig.26.



SECTION P.R.
Fig.27.

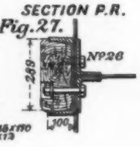


Fig.28.

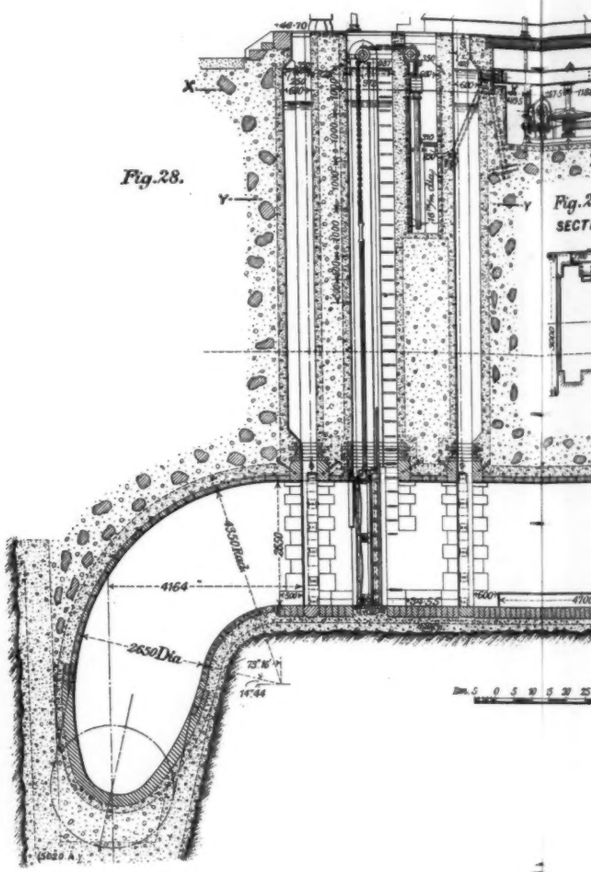


Fig.32. LO

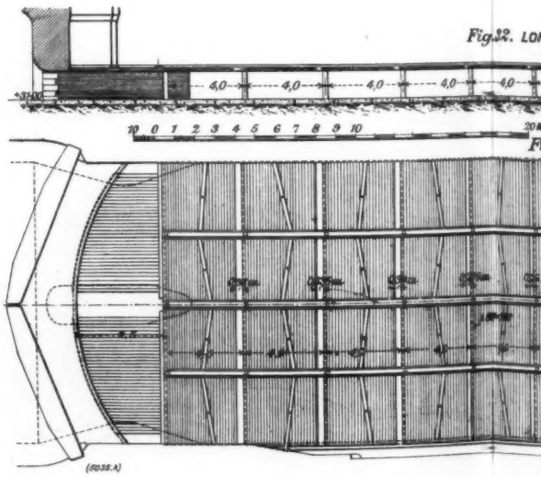
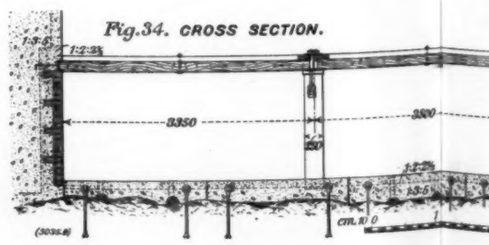


Fig.34. CROSS SECTION.



LS OF FLIGHT OF LOCKS AT TROLLHÄTTAN.

cripti... see Page 596.)

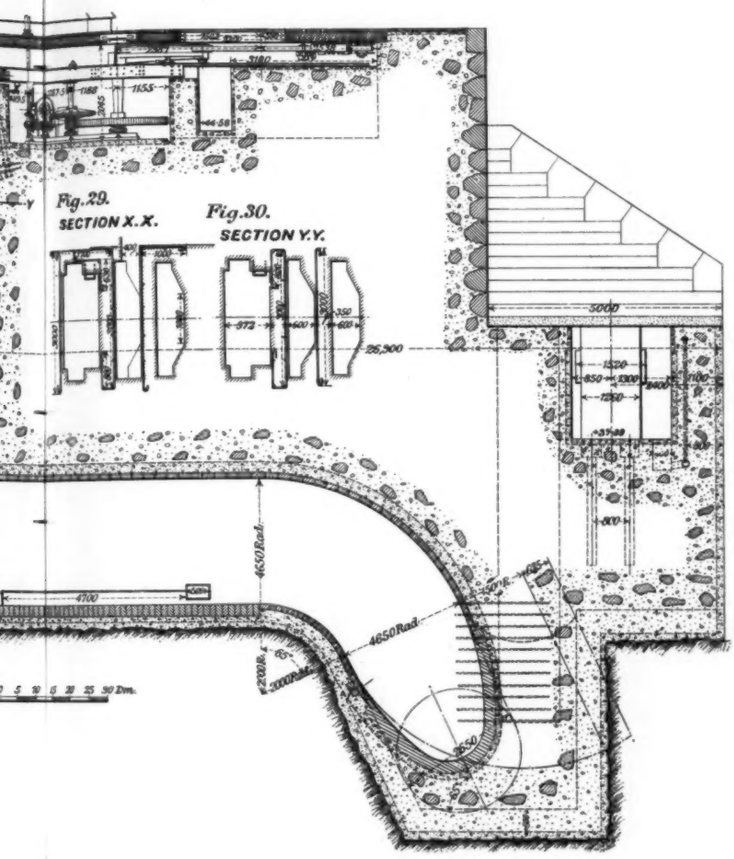
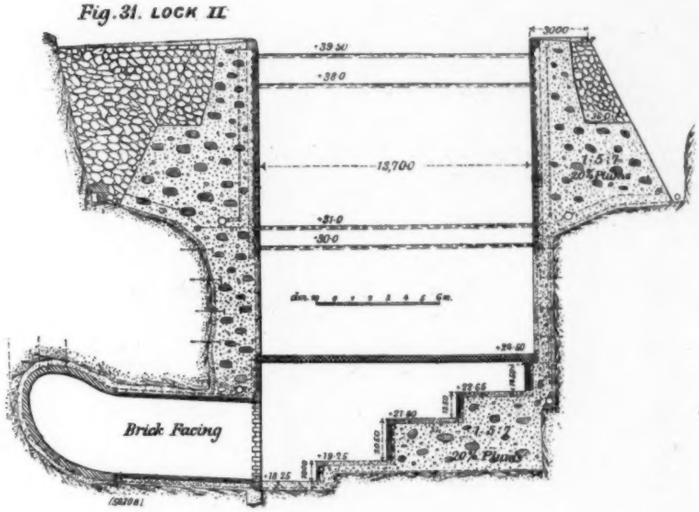


Fig.31. LOCK II.



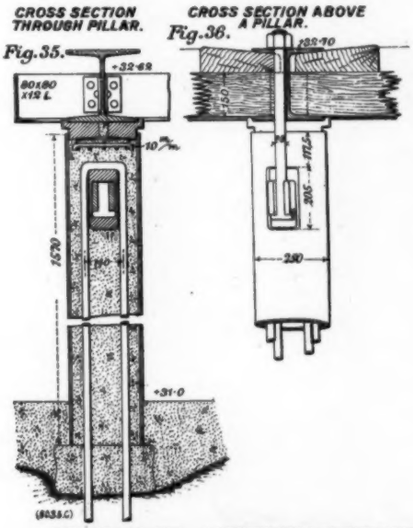
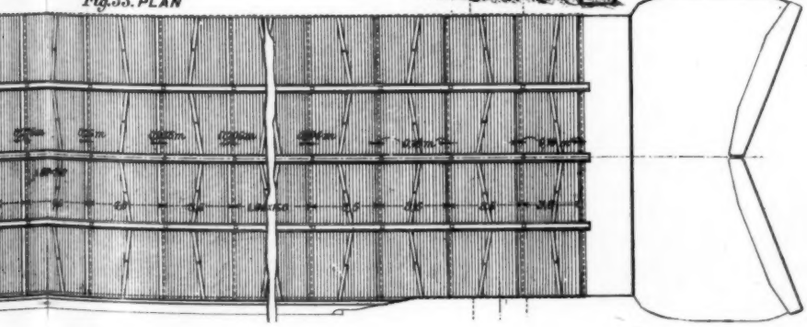
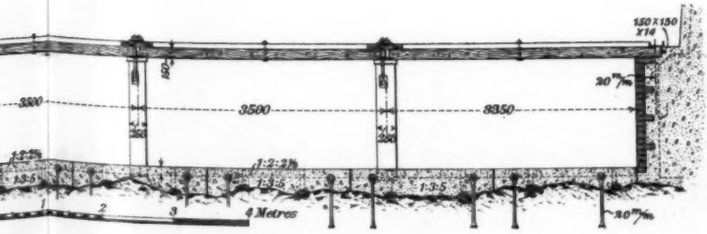
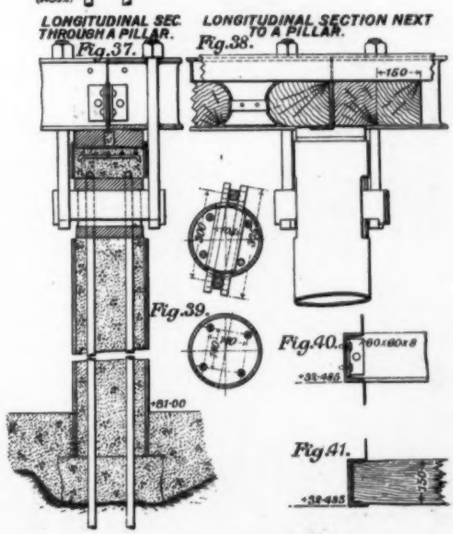


Fig.32. LONGITUDINAL SECTION.

Fig.33. PLAN







were contracted for, as well as the heavy ironwork and the machinery.

Most of the earth removal was done by hand, an excavator of the bucket chain or paternoster type, however, having been employed in some cases. The aggregate quantity of earth removed amounted to 712,455 cub. m. (926,000 cub. yards).

trucks hauled both by Decauville locomotives and electric locomotives. Numerous coffer dams were constructed, so as to make it possible to work in the dry, particularly where extensive blasting operations were required. The blasting work in and close to the old rock canal, which was widened and deepened, entailed much loss of time, as it could

portion of the rock canal work was carried on during the summer months by leaving a wall of rock to act as a coffer dam and keep the new excavation dry.

Some blasting under water was unavoidable, but the aggregate of rock removed in this way, as already mentioned, was only 26,152 cub. m. The

Fig. 1.

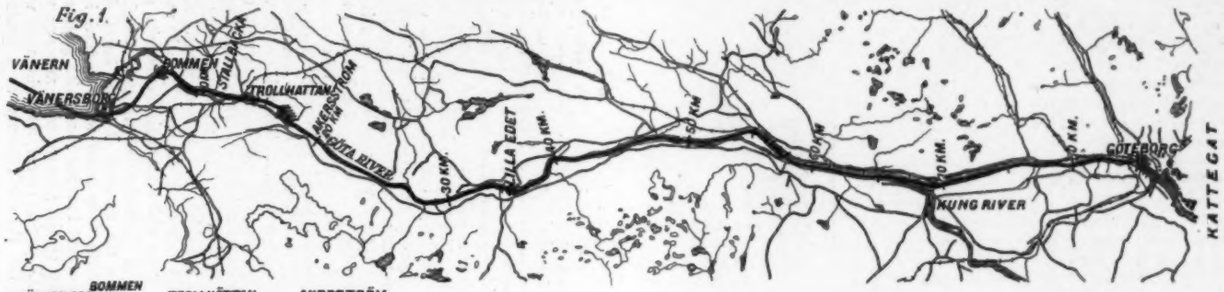


Fig. 2.

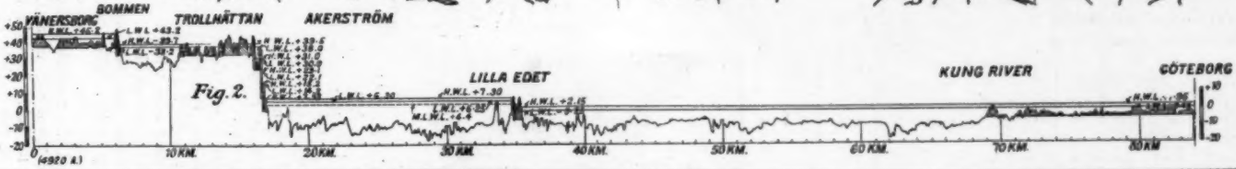


Fig. 3.

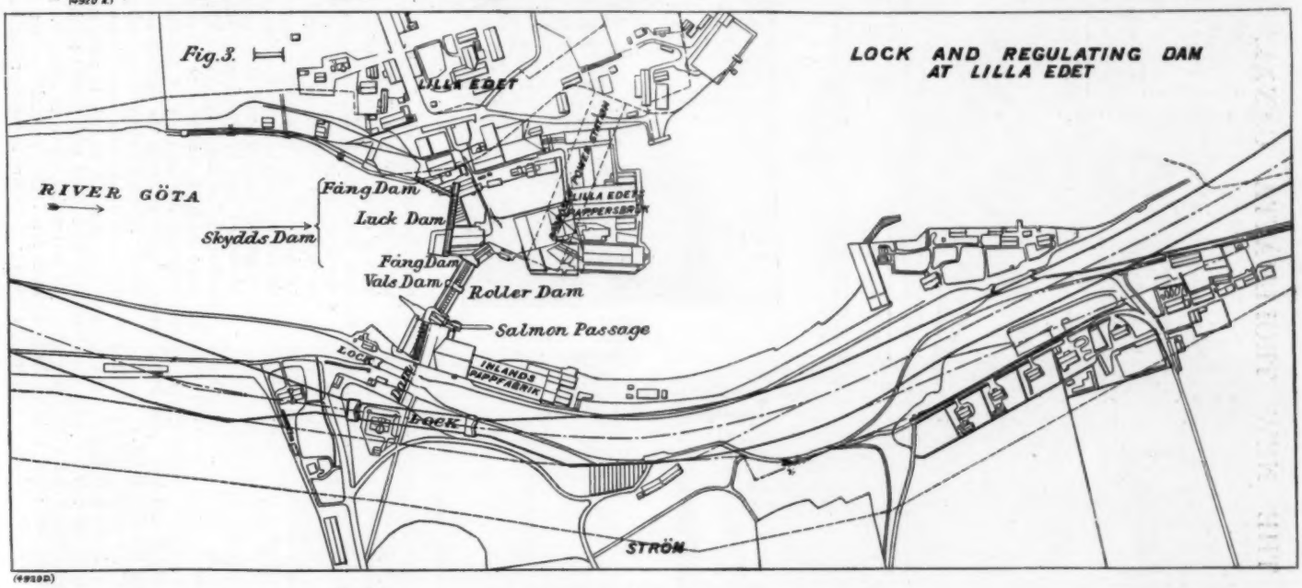


Fig. 4.

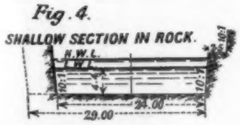


Fig. 6.

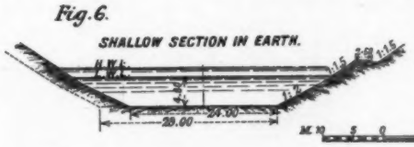


Fig. 8.

Fig. 5.

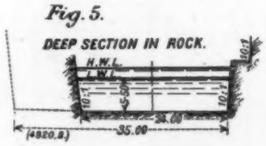


Fig. 7.

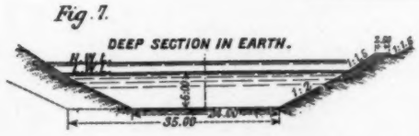
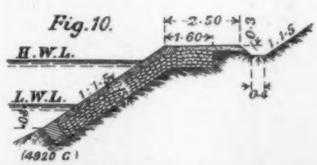


Fig. 9.

In the rock section extensive blasting was necessary amounting in the aggregate to 1,033,882 cub. m. (1,344,000 cub. yards), of which 26,152 cub. m. were below water. At the different locks there was much blasting, more especially at the two contiguous locks already referred to, where the quantity of rock blasted amounted to 296,095 cub. m. Also along the so-called rock canal blasting had to be resorted to on a large scale. For the blasting operations rock drills worked with compressed air from electrically driven compressors were mostly employed. The blasted rock was loaded by hand cranes on to Decauville

Fig. 10.



only be undertaken during the winter, when the canal traffic was suspended, about 3 months each year. As soon as navigation stopped, about Christmas time, the whole of the rock canal was laid dry and the work went on during the winter. In the lower drilling was done through pipes projecting above the surface of the water, and the dynamite charges were also deposited through pipes, and electrically fired in groups. The dredging operations effected the removal of 2,364,312 cub. m. (3,074,000 cub. yards) of clay, mud, stones, &c. A new breakwater, 340 m. (1,115 ft.) long, built of excavated rock, was constructed at the inlet to the canal from Lake Vänern.

Two dams were built in connection with the new waterway, viz., an earth dam at Brinkebergskulle and a regulating dam, already mentioned, at Lilla Edet. The former is a fixed dam, consisting

THE NEW TROLLHÄTTA CANAL.

Fig. 11

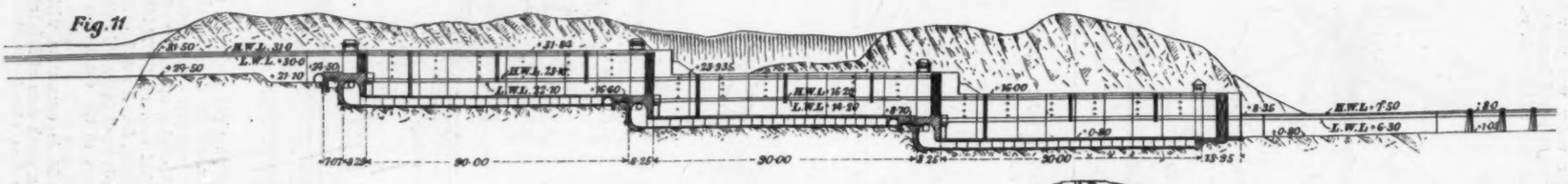


Fig. 12

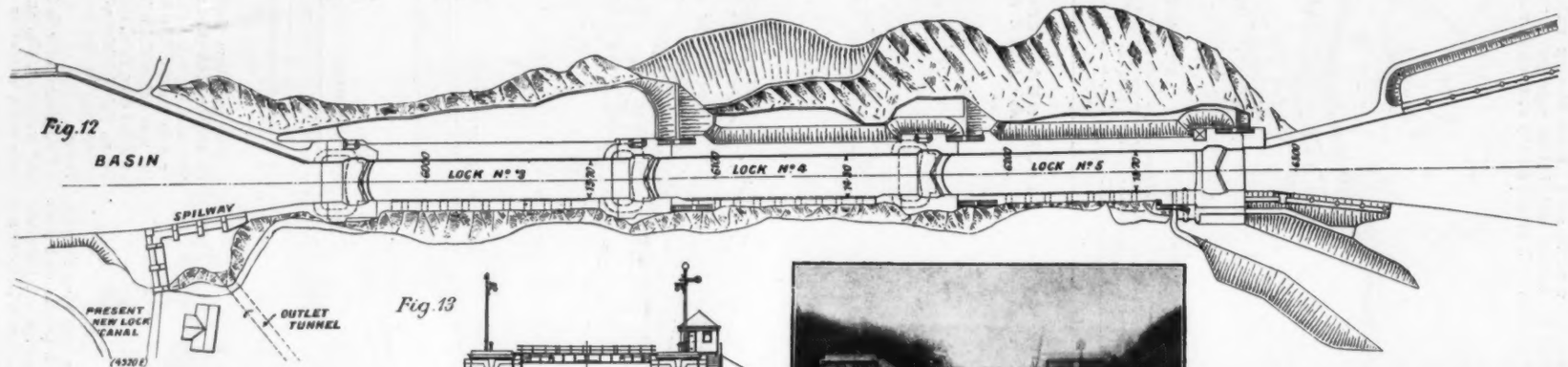


Fig. 13

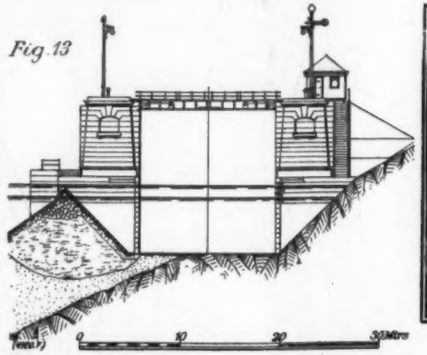


FIG. 14.

of two sections, one on the east and one on the west side of the lock, the object being to raise the level of the water above the dam to the same level as that of Lake Vänern. Both dams are constructed of excavated rock. On the east the rock dam was carried 10 m. (32 ft. 10 in.) down into a 20 m. stratum of clay. Watertightness was secured in the western dam by a steel piling or wall of planks placed at a distance of about 2 m. in front of the rock dam, rising somewhat above high water level. This piling is supported by means of stay bars, 32 mm. (1¼ in.) and 25 mm. (1 in.) diameter; behind the piling is a layer, 1.5 m. (5 ft.) thick, of puddle, the interval being filled up with earth. The western dam is rendered tight by a puddle layer between two timber walls, and this dam has an ice outlet of 5 m. breadth.

The regulating dam at Lilla Edet (Fig. 3) consists of three parts, viz., the dam proper across the river bed, the dam in front of the intake to the Inland Cardboard factory, and the protecting dam in front of the inlake to the Lilla Edet paper mills. The dam across the river bed has two spillways, each with a free breadth of 22 m. (72 ft.), which are closed by roller dams. The two other dams are designed to protect the mills against the increased height of water in the river.

The locks are six in number, one at Brinkebergakulle, four at Trollhättan and one at Ström. Of the four Trollhätta locks the three lower are connected, forming a flight, as shown in Figs. 11 and 12, annexed, whilst an elevation of the entrance is reproduced in Fig. 13. In Fig. 14 we reproduce a photograph which shows this entrance in course of construction.

The lifts in the locks vary according to the water-level of the river; at mean water-level they are as follow:—

Lock:	
No. 1, at Brinkebergskulle	5.7 m. (18.7 ft.).
No. 2, at Akersberg ...	7.95 m. (26 ft.).
No. 3, at the basin in the lock flight	7.88 (25.8 ft.).
No. 4, at central lock ...	7.82 m. (25.6 ft.).
No. 5, at Holmen ...	7.87 m. (25.8 ft.).
No. 6, at Ström	5.4 m. (17.7 ft.).

The greatest lift is at the Akersberg lock, where, with high water above and low water below the lock, it may amount to 9.5 m. (31 ft.).

Water can be let into and out of the locks through culverts constructed in the masonry on the sides of the gate chambers. The culverts are placed on each side of the lock, except at the Akersberg lock, where the inlet culverts are placed only on the east side of the lock, and at the Holmen lock where the outlet culverts are placed only on the west side of the lock. From the upper side of each lock a bottom culvert proceeds below the bottom of the lock, into which it delivers. The outlet culverts also lie below the floor of the lock. The flow of the water in the culverts is regulated by means of vertical sluices. When these have to be repaired the conduits can be closed by other means.

The lock gates are worked by mea[illegible] of electrical winches, placed in chambers in the side masonry entirely below the lock plane. The locks are also fitted with electric haulage windlasses and with bollards. All the electrical machinery, except the haulage windlasses, the lighting and the signalling lamps, is controlled from operating cabins. The cables are laid in cable tunnels below the locks.

The locks are entirely in rock, and the concrete masonry is faced with granite on the upper part of the water side, down to about 0.8 m. below low-water level. The general character of the work is clearly illustrated in the reproductions from photographs given in Figs. 15 to 18, page 599, and Figs. 19 and 20, page 600. The side walls are of three different types. They are either walls standing entirely free on the rock, or with the upper part free and the lower part forming a facing to the rock, or as piers resting against the rock, with walls between them. In addition, a complete masonry facing to the rock has been adopted in some places, viz., in that portion between the gate chamber and the piers. The choice of these different systems has depended upon the condition and position of the rock. Where the rock was firm and where it was possible to blast it with vertical sides, the pier construction has been used (see Figs. 17, 19 and 20. It consists of concrete piers, 2 m. (6 ft. 7 in.) broad, at intervals of 5 m. (16 ft. 5 in.), covered at the top with a layer of ferro-concrete, with gravel above. The thick walls were made of 1, 5, 7 concrete, and the smaller walls of 1, 3, 5, with a waterproof layer along the bottom and outer sides of 1, 2, 2, 5. The granite coating is 245 mm. (9⅝ in.) thick, with 10 mm. joints. The walls were built as monoliths, generally in 10 m. (32 ft. 9 in.) lengths, with intermediate expansion grooves.

The dimensions of the gate chambers depended upon the amount of plant installed there. The culverts were faced with vitrified brick in some parts and in other parts with granite. The upper sides of the gate-chamber masonry were set with small paving stones, and reinforced with iron rods in the thinner masonry as a protection against changes of temperature. Where the rock at the bottom of the lock was unsatisfactory it was covered

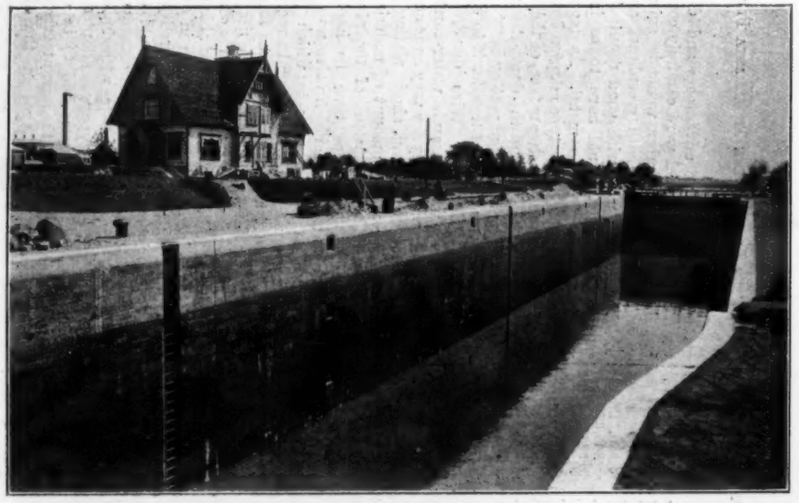


FIG. 15. LOCK AT BRINKEBERGSKULLE.

FIG. 16. UPPER GATES AT BRINKEBERGSKULLE LOCK.

FIG. 17. LOCK AT AKERSBERG, SHOWING ROOF OF BOTTOM CHAMBER IN COURSE OF CONSTRUCTION.

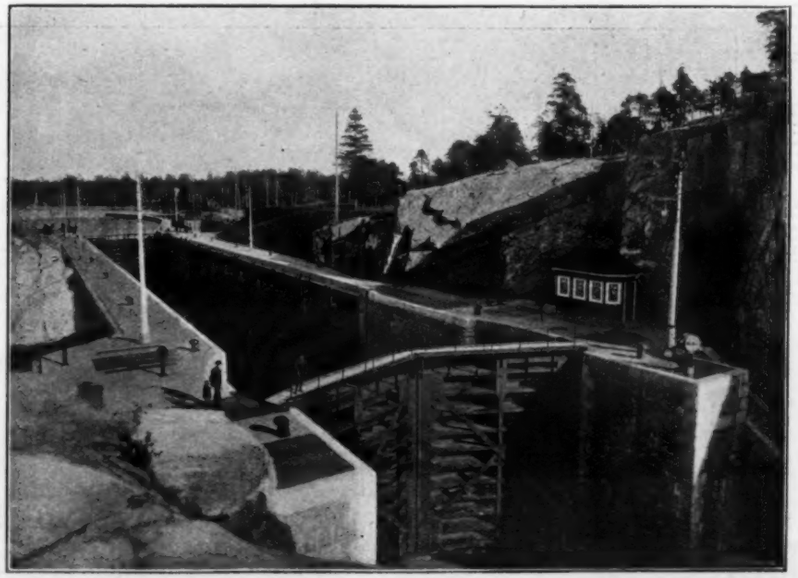


FIG. 18. GENERAL VIEW OF AKERSBERG LOCK.

THE NEW TROLLHÄTTA CANAL.

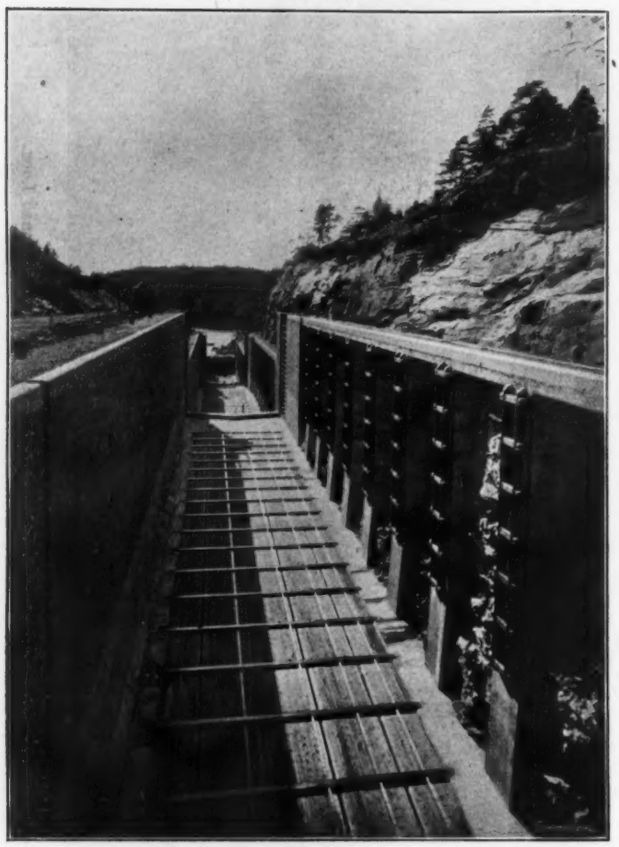


Fig. 19. New Locks at Trollhättan Viewed from Above.

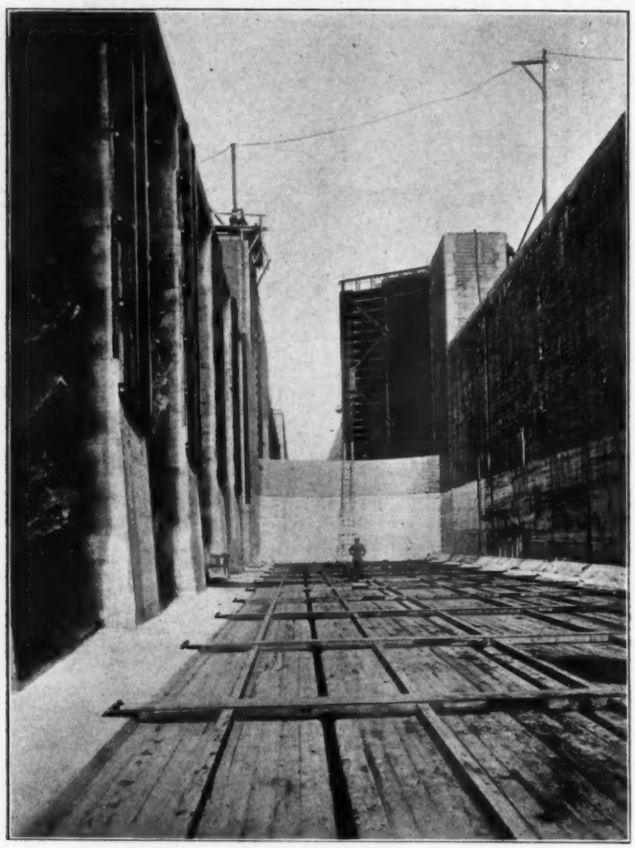


Fig. 20. Interior of Lowest Lock of the Trollhatta Flight.

with masonry, and at the Ström lock the bottom was finished with an invert arch, the greater part of the length of the lock.

The culverts were constructed in two sizes, viz., one of 2.9 m. (9½ ft.) height and 2.2 m. (7¼ ft.) breadth, and another of 2.65 m. (8¾ ft.) height and 2 m. (6½ ft.) breadth. The larger dimensions were adopted at the Akersberg lock and at the upper and lower gate chambers in the lock flight. In all other cases the smaller dimensions were adhered to.

A water chamber was constructed under the entire bottom of each lock and the top or roof of this chamber has openings to let the water through.

The gates can be opened by the electrical gear in 45 seconds, and they can also be opened by hand by two persons. The electric gear can commence to open the gates with a difference in water level of 15 cm. (6 in.).

The sluice gates in the culverts are of the Stoney type. The gates are built up of buckle plates riveted to a steel framework. They are suspended by two chains which travel over pulleys and carry counterweights at the other end. They are raised or lowered by electric gearing. The electric motors are either of 5 and 10 h.p. according to the load. The maximum hoisting speed is 0.15 m. (6 in.) per second, and the aggregate time for hoisting varies between 1 and 2.5 minutes, according to the lock at which the doors are used.

The expenditure on the new Trollhätta canal up to July 31, 1916, amounts to a total of 21,758,865 kroner (1,208,826*l.*). The estimate will probably be exceeded, on account of the rise in prices, but only by some 2–3 per cent. Of the more important items there may be mentioned :—

	Kroner.*
Preliminary work, drawings, &c....	472,568
Acquirement of land, &c.	2,078,053
Earth removal	1,391,407
Dredging	1,946,279
Blasting, above water	4,380,719
Blasting, below water	805,800
Shore protection, walls, &c. ...	531,205
Cofferdam construction	443,247
Lock construction, masonry, &c. ...	2,944,216
Lock gates, winches, &c.	976,108
Bridges	1,283,518

* 18 kroner = 1*l.* at normal rates.

The work in connection with the new Trollhätta canal has been carried out under the auspices of the Royal Waterfalls Board, of which Colonel F. Vilh. Hansen is the chairman.

The traffic on the canal during last year amounted in the aggregate to 9,759 vessels, with an aggregate tonnage of 870,668 tons; of this total 7,827 were steamers, 664 sailing vessels and 1,268 barges. The largest number of vessels which in the course of 24 hours have so far passed the canal is 104. The weight of goods passing through the canal in 1915 was 500,019 tons up and 785,952 tons down, but these quantities, on account of the war, were materially lower than those for 1913.

Several towns on Lake Vänern and thus directly interested in the new Trollhätta canal, have undertaken considerable works so as to meet the requirements of the increased traffic, and the city of Gothenburg has also carried out the necessary work in this connection. Of the more important shipping canals in the old and the new world only five are larger than the Trollhätta canal.

The general design of the lock gates was fixed after a very comprehensive survey of the whole problem. The design actually adopted is illustrated in Figs. 21 to 27, Plate LVI. As for materials, the relative advantages and disadvantages of wood and steel were carefully considered, but as no Swedish timber would be suitable for such large gates, and both greenheart and teak, which have been used with good results for such purposes elsewhere, would have to be imported, preference was given to metal. As regards the construction, gates of the type adopted have either single plating on the up-stream face, or they may be plated on both the up and the down-stream sides. In both cases the up-stream plating has to directly support the water load and transfer it to the girder framework of the gate. With double plating, part or all of the weight may be water-borne. This system is used accordingly for very large and heavy gates. On the other hand, single plating requires a substantially smaller amount of material in the gate proper. The dimensions of the pivots and hinges must at the same time be kept within reasonable limits and should involve no excessive expenditure on the masonry to which they are secured, nor must inordinate power be required for operation. In the present case it was found that the diameter of the pivots in no case need exceed 160 mm., which is not a particularly large dimension, that the side walls would be quite capable of withstanding the forces imposed on them in operating the gates, and that the power required for overcoming the frictional resistances at the pivot would not amount to 1 h.p. There was consequently no drawback involved in using gates with single plating at Trollhättan, and this type was adopted accordingly. Besides, if the gates had to be operated when the lock was empty, the advantages of double plating became disadvantages in the shape of increased friction and greater strains on the anchorage. As examples of gates of about the same

dimensions as those at Trollhättan and fitted with single plating may be mentioned the gates of the Erie Canal.

A fender chain has so far only been adopted at the upper gate chamber at Akersberg. It consists of a 45 mm. (1¾ in.) short-link chain, which under ordinary circumstances hangs in a groove in the sides of the lock chamber, and in the bottom, and which, when required, can be hoisted and drawn across the lock inlet. The chain is anchored, with a powerful spring, at the upper edge of the masonry on the west side of the lock inlet, and can be raised or lowered by means of a winch, located in a separate chamber in the masonry on the east side. When the chain is raised it is automatically coupled to a counterweight heavy enough to keep it tight and to offer an effectual resistance should a vessel come in contact with it, so that the shock of the impact is never transmitted to the winch. The counterweight consists of concrete, encased in an iron box, which hangs in a shaft in the masonry. The counterweight is fitted with a centrifugal brake for regulating its speed in falling. The winch is worked by an electric 20-h.p. motor, and can also be operated by hand. The chain can be hoisted in 30 seconds. The strength of the chain is calculated for the largest vessels which can ply on the canal; such vessels, fully loaded, are assumed to weigh 6,000 tons, and the greatest speed at the lock entrance to be 0.6 m. per second (1.4 miles per hour).

Two warping winches have been installed at the Akersjö lock, both on the eastern wall. The machinery of the winch is placed in a watertight box of cast iron, below the plane of the quay; the speed of the rope can be either 0.25 m. (9.8 in.) or 0.42 m. (16.5 in.) per second. The winch is fitted with an adjustable friction clutch which will slip at a determined stress. The motor is of 20 h.p.

Bollards are fixed on both sides of the locks; they are of cast iron, 25 mm. (1 in.) thick at the bottom, 30 mm. (1.2 in.) near the top, projecting 0.8 m. (31½ in.) above the ground and inserted 1 m. into the concrete. Electrically worked winches for passing the vessels' ropes from lock to lock are placed at the ends of the locks.

There is a control cabin opposite the centre of each gate chamber, from which the different winches on both sides of the lock are operated. Electric lamps of 200 candle power are erected on poles of ferro-concrete on each side of the lock, the end poles at one side also carrying signal lamps.

For the purpose of closing and emptying the locks in emergencies special arrangements have been provided at the lower end of the locks. At the lock at Brinkebergskulle this arrangement consists of an horizontal iron girder in the lower masonry serving as a support for vertically suspended frames of Differdinger girders, between which wooden doors are lowered so as to cover the entire lock opening. For emptying the locks Nos. 2, 3 and 4 at Trollhättan it is only necessary to lower the water-level in the basin or lock below. For emptying lock No. 5 an arrangement has been adopted somewhat similar to that used at Brinkebergskulle. Lock No. 6 can be emptied by the construction at the lower end of a cofferdam of 14 horizontal iron girders, resting in grooves in the masonry and made tight by horizontal wooden battens. For emptying the cable tunnels and valve shafts there are three movable electrically worked shaft pumps of a capacity of 500 litres (110 gallons) per minute each. For closing the Trollhätta canal for new work or repairs a floating pontoon, 31.3 m. long, 3.2 m. broad and 1.3 m. high, is inserted into recesses in the shore supports of the Trollhättan street bridge; on this pontoon there is a vertical frame carrying doors and serving to close the canal.

For regulating the water-level in the basin below the upper lock at Trollhättan, which is liable to fluctuations dependent on the flow of traffic, an inlet channel has been constructed on the east side of the Akersjö lock, with gates at the upper end; the section of this canal is 2.5 m. (8 ft. 2 in.) high and 3.5 m. (11 ft. 6 in.) wide. For letting water out from the basin an outlet canal to the river has been blasted, of the same dimensions as those of the inlet canal and fitted with four spillways of 7 m. (23 ft.) length, one of 2.75 m. (9 ft.) length, and four siphons, each with an outlet area of 2.8 by 1.8 m. (110 in. by 70 in.).

The new dock at Trollhättan is designed for vessels of 4 m. (13 ft. 1½ in.) draught; the breadth at the entrance is 10.8 m. (35 ft. 5 in.); greatest length 75 m. (246 ft.) and minimum depth on sill 4 m. (13 ft. 1½ in.).

The Arrangement of the Locks.—The inlet culverts are, except at lock II, placed one on each side of the upper gate chamber and lead into a sump underneath the gate chamber (except at lock II, as will be explained later), which sump is intended to serve as an equalising reservoir for the water flowing into the lock. From the sump a water chamber extends below the lock, the roof of the chamber forming the bottom of the lock. The arrangement will be clear on reference to Figs. 32 and 34, Plate LVI. The roof is of timber supported on reinforced-concrete pillars, details of which are illustrated in Figs. 35 to 41. In this roof there are openings for the passage of the water. The water enters the lock from below, its upward flow being fairly uniform over the whole section, and thus does not give rise to much disturbance.

The outlet culverts proceed from the lower portion of the bottom channel, and deliver into the waterway below the lock. On account of local conditions at lock II the inlet culverts have been placed on one side of the upper gate chamber, and at lock V the outlet culverts are located on the one side of the lower gate chamber (see Figs. 31). At the intermediate gate chambers in the flight of locks the culverts also proceed from the lower ends of the bottom channels and deliver into sumps beneath the gate chambers. The flow of water in the culverts can be regulated by means of vertically working sluices or penstocks (see Figs. 29 and 30, Plate LVI. In order to be able to repair the latter the culverts can be separately shut off on each side of the sluices (see Fig. 28, Plate LVI), and the intermediate space emptied by pumping.

(To be continued.)

AMERICAN SHIPPING AND SHIPBUILDING.

THE position and prospects of United States shipping and shipbuilding are provoking considerable speculation just now, and a few facts and circumstances relating to American conditions may usefully be set out. In view of her resources up to a few months ago and her available volume of skilled labour, America is now doing wonderfully well. Thus she is playing, and will play, a highly welcome part in helping to solve the shipping problem, and it is not unlikely that after the war that country will be our chief rival on the ocean carrying trade as she was in the first half of the nineteenth century.

In the middle of the last century the Americans came near to beating us in ocean shipping; and history may possibly repeat itself. Ambitious plans are being made for a permanent revival of the United States merchant marine. But we may rest assured that we shall not experience from America that kind of State-subsidised and bounty-fed undercutting of freights and passenger rates that characterised German competition before the war, and will govern it again if we take no measures to check it. American competition will be fair and above-board. If, as is probable, American shipping is subsidised, it will only be to an extent sufficient to balance the difference between costs at home and abroad, in strict accordance with the protective principle of United States law. It will not be done, as in the case of German subsidisation, with the set intention of destroying our position as a shipping nation.

Since the war started more than 50,000,000*l.* of new private capital has been invested in American shipping enterprises, and perhaps an equal amount in shipbuilding. A Federal Shipping Board has been appointed with power to raise almost unlimited sums of money for the building, purchase and hire of vessels; and large amounts have been spent on extensions and improvements of the naval yards. When war broke out the tonnage of United States shipping engaged in foreign trade was only, in round figures, 1,000,000 tons, though the country possessed about six times that tonnage employed in the lake, river and coastal trades. Britain had 18,000,000 tons of ocean shipping, and Germany 5,500,000 tons. Only about 8 per cent. of America's oversea commerce was carried in American vessels.

The great boom in American shipbuilding and its twin trade shipping is not, however, a creation of the war, though it has been accelerated by war. It is part of a national movement for more ships, inaugurated before and apart from the war. More than twenty years ago a Merchant Marine League was formed in the United States to advocate the restoration of shipping. When it was found that the Panama Canal was at last likely to be opened to traffic the "more ships" question became one of practical politics. How far the current revival will be carried—how far American shipping will rise in the international scale—whether we shall be closely run or beaten by the Americans—will depend partly upon the measures that are taken to foster United States shipping, and partly upon our own efforts to maintain our supremacy. If our workmen and their unions are unreasonable, if our engineers will not adopt standardisation and other economical methods, if our builders will not co-operate and combine, and if our statesmen will not recognise the rights of enterprise and stop unfair foreign competition, then nothing can prevent such a growth of American and German shipping and such a decline of our own as will spell the downfall of the British Empire.

The central and supreme fact is that we possess such great natural and economic advantages in shipping and shipbuilding that we ought easily to maintain a very long lead in these lines. With our coal and iron supplies, our steel works and building yards and harbours all practically side by side, with our unique geographical situation, with our great building capacity and inherent skill in this trade, we hold a combination of special favours. These advantages enabled us, before the war, to build and sail ships more economically than any other nation. But what of the future? Some authorities consider that one result of the war will be the removal of the great difference between British and American costs which has hitherto existed.

HYDRAULIC TESTER FOR GAS STORAGE CYLINDERS.

WE illustrate on page 602 plant constructed by Mr. James Spurge, of 45, Greek-street, Soho, for the rapid and convenient testing of the cylinders used for storing the various gases now so largely used in different industries. The pressures to which these cylinders are subjected are extremely high, and it is the practice accordingly to anneal them at frequent intervals, and to subject them to an hydraulic test before again passing them into service. This test is directed in the main to ascertaining whether the normal working pressure which the cylinder will have to carry will be likely to strain it above the elastic limit of the metal. The test is based on the fact that if the elastic limit be not exceeded under the test pressure the cylinder will recover its original volume when the pressure is relieved.

The general arrangement of Mr. Spurge's apparatus is illustrated in Fig. 1, but the principle on which it is based will perhaps be more clearly understood on reference to the diagrammatic view represented in Fig. 2. The apparatus consists of a pump C operated by the hand lever shown, and connected on the suction side to the graduated glass tube E indicated on the left of the diagram, and on the delivery side to the bottle under test. Suppose the bottle full of water to be coupled up to the branch B, and the valve L open whilst the valve at A is closed, and the pump plunger is at its furthest home position, to which it is brought automatically by the weight of the levers when the bye-pass valve N is open. If this valve N be open the water will stand at a certain height in the graduated tube. This tube can be connected by the cocks indicated with the town supply, and with an overflow tube shown. If both these cocks are open the water in the graduated tube will rise to a height fixed by the overflow level. If the cocks are now closed the water trapped in the apparatus above the bottle junction will always be a fixed amount. On closing the bye-pass, the cylinder can be put under pressure, which is read from the gauge indicated, and the valve L is then closed; subsequent to this the by-pass valve is opened and the pump plunger is run back to its original position. All the water which has been forced

PLANT FOR TESTING GAS STORAGE CYLINDERS.

CONSTRUCTED BY MR. JAMES SPURGE, ENGINEER, LONDON.

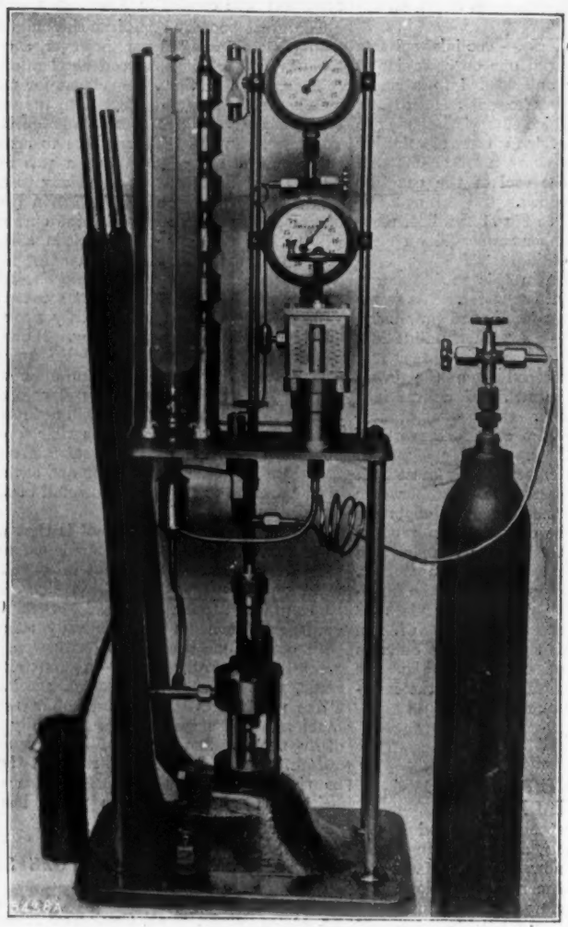


FIG. 1.

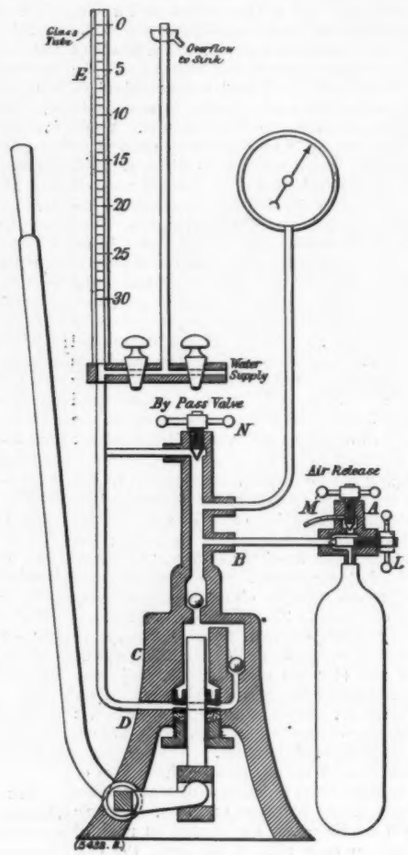
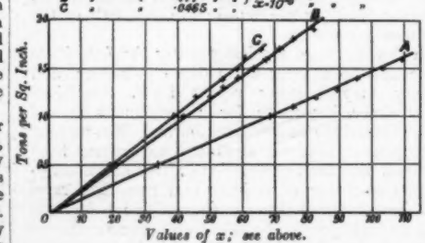


FIG. 2.

into the cylinder has been withdrawn from the graduated tube, and the amount can thus be read off and compared with the pressure-gauge readings. On now opening the valve L the water which has been compressed in the cylinder flows back into the graduated tube, and if there has been no permanent set the level attained is the same as before the test. Any change of level indicates and measures a permanent change in the volume of the cylinder.

In the practical operation of the machine the cylinder is, as a preliminary, put under a moderate pressure, the valve L closed, and that at A opened, so that any air entrapped escapes through the vent at M. This operation is repeated two or three times until all the air is got rid of before proceeding to the definite test. The accuracy of the apparatus would be vitiated by any leakage, and accordingly provision is made to trap any leakage past the U-leather packing of the pump plunger. This is effected by having an additional stuffing-box outside of this packing and carrying the suction passage through the interspace between the two packings. The outer packing is never subjected to any appreciable pressure, and is easily made perfectly tight, and as any leakage past the U-leather is trapped the quantity of water included within the system remains invariable, and the difference in the readings of the graduated tube measures accurately any permanent set of the cylinder. The apparatus, as shown complete in Fig. 1, differs merely in detail from that illustrated diagrammatically in Fig. 2. The overflow tube is replaced by two "containers" shown mounted on the table to the left and right of the graduated tube. These containers hold a fair quantity of water and enable large cylinders to be tested. Either or both containers may be included or excluded from the water circuit, by a cock provided for the purpose. One of the containers is fitted with an

Fig. 3. GAS CYLINDERS: ADDITIONAL WATER HELD UNDER PRESSURE, UP TO ELASTIC LIMIT.
A Water Capacity ·648 Cu. Feet} $x \cdot 10^{-4}$ cub. feet held.
B " " ·477 " "
C " " ·0465 " "



Values of x; see above.

overflow, and the water level is adjusted by means of this overflow at the start of every experiment in the manner already described. The volume of water forced into the cylinder and any permanent set of the latter is measured by means of a "volumeter" shown mounted on the table to the right. This is essentially a vessel fitted with a plunger operated by a micrometer screw. Volumes are measured by screwing in this plunger till the original level of the water is restored. The quantity is then read off the divided head.

In practice the method is to note first from the level of the water in the gauge glass how many of the small compartments of the container on the right are completely empty. One will be partially empty and the plunger of the volumeter is run in until this is just filled. The number of wholly empty containers, plus the displacement of the volumeter plunger, shows the amount of water run into the cylinder; the large container comes into use mainly when a cylinder is to be tested to destruction.

Two levers are fitted for working the pump, as with high pressures the force necessary is rather beyond the strength of one man. There are also two gauges, one of which serves as a check on the other.

A sand glass is mounted near one of the gauges, as indicated, and serves to time the period during which each cylinder tested is maintained under pressure.

TABLE I.—*Tests of Two Cylinders.*

Particulars of Cylinders.	Applied Pressure. Tons per Sq. In.	Additional Water Held. Ounces = 10^{-3} Cub. Ft.		
		Under Pressure.	Pressure Removed.	Permanent.
B.				
Water capacity,	0·5	2·07	·005	·005
0·477 cub. ft.	1·0	4·18	·006	·011
Weight, 52 lb.	1·2	5·0	·009	·020
	1·3	5·41	·005	·025
	1·4	5·88	·005	·030
	1·5	6·34	·012	·042
	1·6	6·72	·006	·048
	1·7	7·14	·008	·056
	1·8	7·58	·018	·074
	1·9	8.22	·367	·441
C.				
Water capacity,	0·5	0·192	0	0
0·0465 cub. ft.	1·0	·388	0	0
Weight, 6·84 lb.	1·2	·456	0	0
	1·4	·540	0	0
	1·5	·582	·01	·01
	1·6	·610	·0	·01
	1·7	·656	·03	0·4

As an example of the behaviour of two gas cylinders, B and C, the above figures, in Table I, are of interest. The observations have also been plotted, in Fig. 3, together with those for a third cylinder, A.

THE 180-H.P. MERCEDES AERO ENGINE.*

THE following report on the design of the new 180-h.p. Mercedes engine is based on an examination of the engine (No. 35,254) taken from the captured German Albatross biplane D.5.A. (G. 97), which was shot down by anti-aircraft fire in the 5th Brigade area on November 14, 1917, and the accompanying data on the design of the engine and the particulars of its general performance, have been compiled from results of tests carried out at the Royal Aircraft Factory.

The 180-h.p. Mercedes engine is the first engine of a new type to be used in service since the advent of the 260-h.p. Mercedes engines in the early part of last year. These 260-h.p. engines were apparently so successful that the 160-h.p. type have since been remodelled so as to introduce several of the leading features of the 260-h.p. practice. The result is seen in the 180-h.p. model, with which this report deals. It necessarily follows from the above that this report will partake more or less of the character of a comparison between the 160-h.p. and 180-h.p. models. Frequent reference, therefore, is made in the text to the 160-h.p. engine, and, in addition, a table is given, showing the leading engine data of the two engines.

In many respects the design of this new engine (see Figs. 1 and 2, page 610) is similar to the 160-h.p. Mercedes, which is now obsolescent. The cylinders are of the same construction and of the same bore and stroke as the 160 h.p., *i.e.*, 140 mm. by 160 mm., as also are most of the reciprocating parts; in fact, this engine might well be termed "The new 160-h.p. Mercedes."

Briefly described, the 180-h.p. Mercedes is a combination of the 160-h.p. and the new 260-h.p. Mercedes engines, and in view of this fact it will be unnecessary in this report to deal at length with the details of the design of those parts which are identical with the components of the above-mentioned engines, of which fully detailed reports have already been issued, and the design of which is now well known in this country. In comparison with the standard type 160-h.p. Mercedes, the new engine shows a marked improvement, both in the design as a whole and in its general performance during power and consumption tests, and as a comparison between the two the leading particulars of the engines are given in the table on page 604.

CONSTRUCTIONAL DETAILS.

Cylinders.—The six separate cylinders are of exactly the same construction as those used in the standard 160-h.p. Mercedes engines, being built up entirely of steel, with the valve pockets screwed and welded into the cylinder heads, and the water jackets of pressed sheet steel welded in position. The pistons also follow the standard Mercedes practice and are similar to those used in the 160-h.p. engines, being constructed with concave heads machined from steel forgings, which are screwed into the cast-iron skirts of the pistons and welded in position. Three rings are provided above the gudgeon pins and one ring below which is situated at the base of

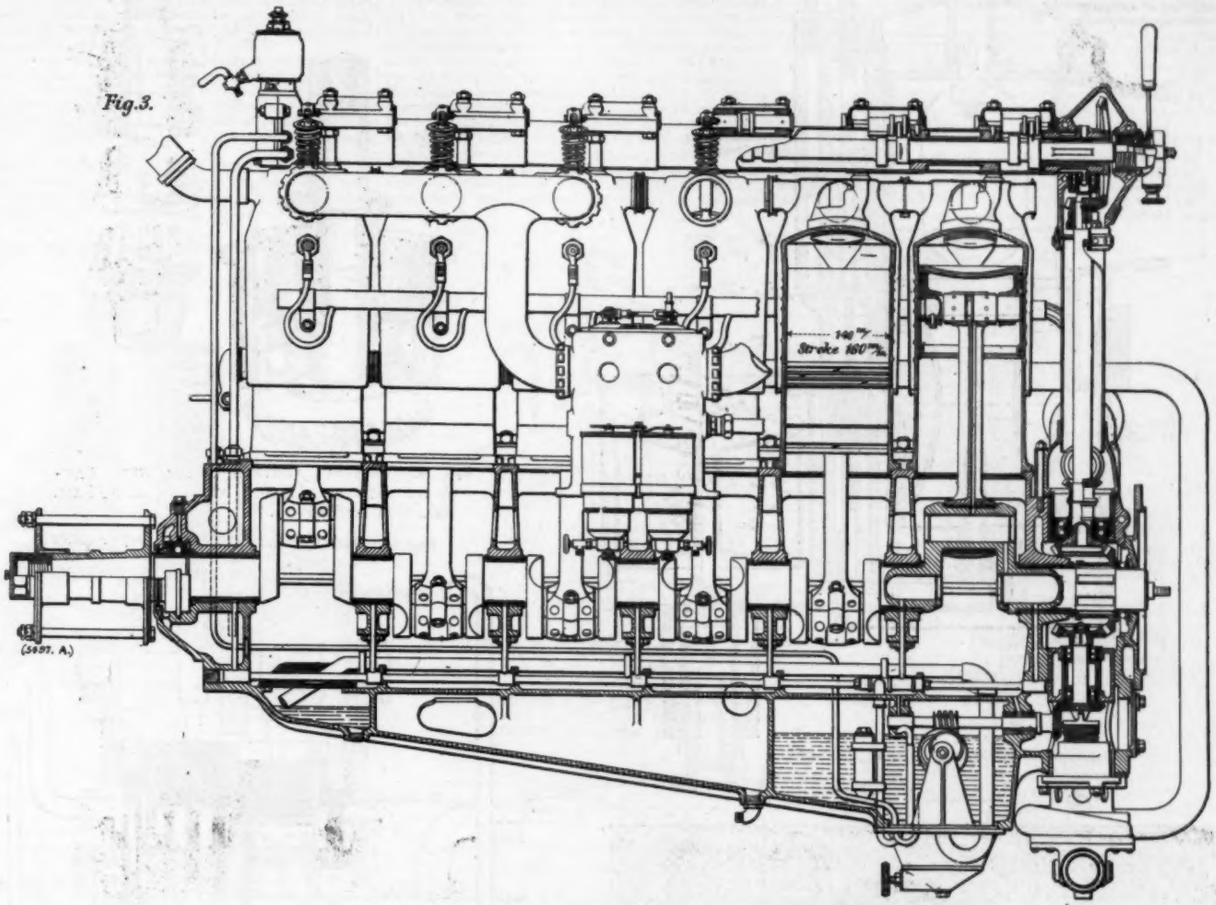


Fig. 3.

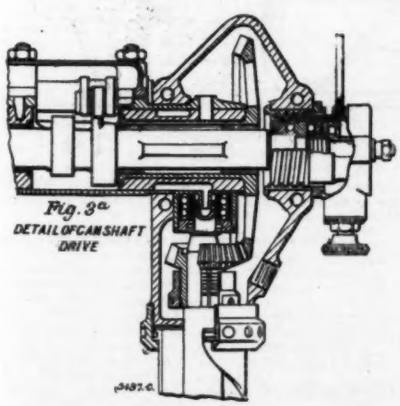


Fig. 3a. DETAIL OF CAMSHAFT DRIVE

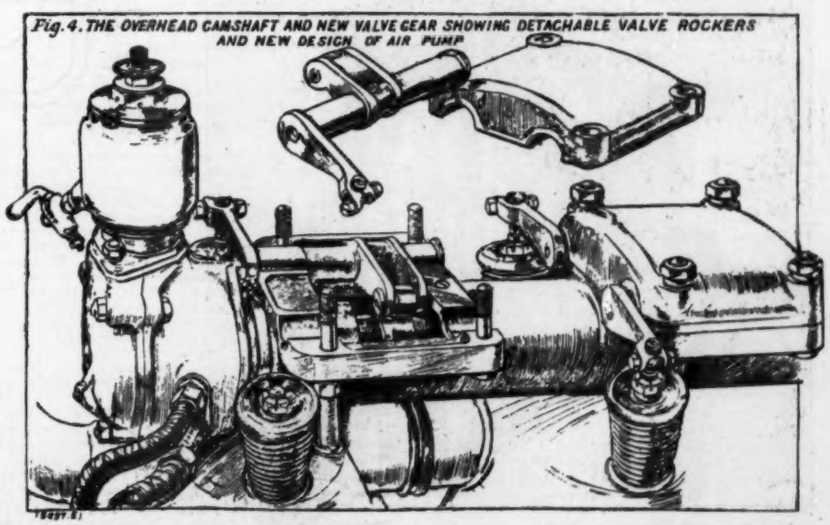


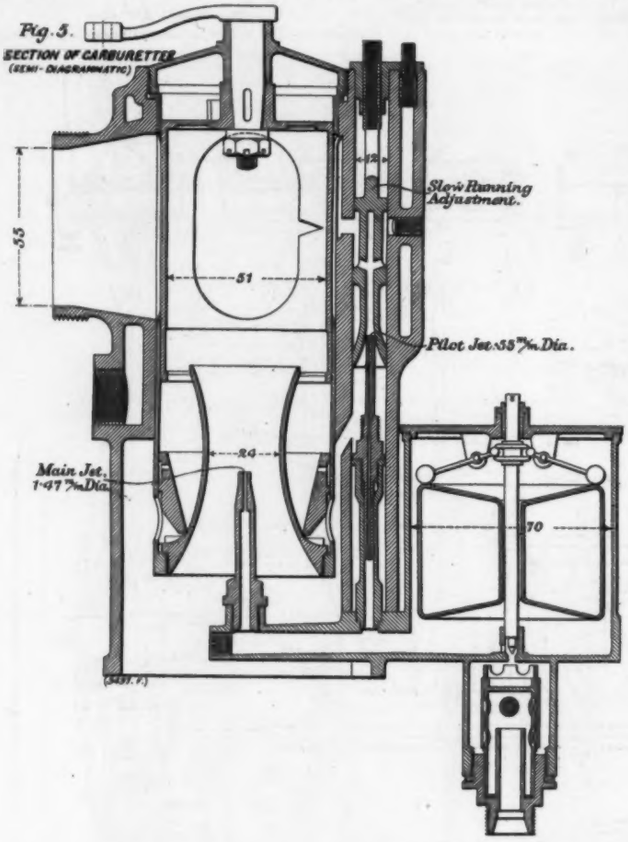
Fig. 4. THE OVERHEAD CAMSHAFT AND NEW VALVE GEAR SHOWING DETACHABLE VALVE ROCKERS AND NEW DESIGN OF AIR PUMP

* Report issued by the Ministry of Munitions, Technical Department—Aircraft Production, and placed at our disposal for publication

the skirt. The gudgeon pins are carried in lugs machined in the lower part of the steel piston crown. The compression ratio is slightly higher in the new 180-h.p. engines, being 4·6 : 1, as compared with 4·5 : 1.

Connecting Rods.—The H-section connecting rods with method of lubrication of the journal and connecting rod bearing are the same, as shown in the general arrangement of the engine, Fig. 3, page 603.

Crank-case.—The crank-case, whilst following the general construction of the 160-h.p. Mercedes engines, of each cylinder, which work at an angle of 15 deg. to the central axis of the cylinder, are interchangeable as in the 160-h.p. engines and are of similar design; the valve-operating gear is, however, of new design, and follows more the construction of the valve gear on the 260-h.p.



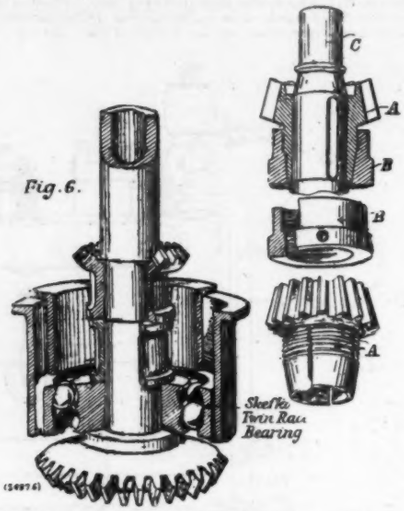


FIG. 6.—VERTICAL DRIVING SHAFT WITH CAM-SHAFT DRIVING PINION AT TOP AND BALL BEARINGS AT BOTTOM.

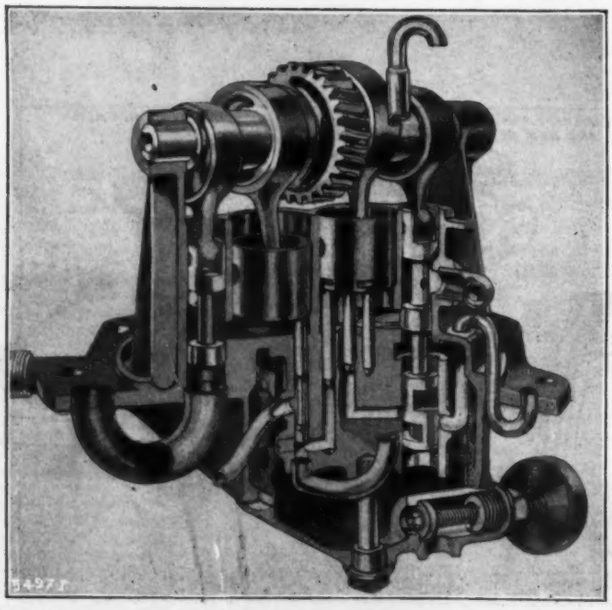
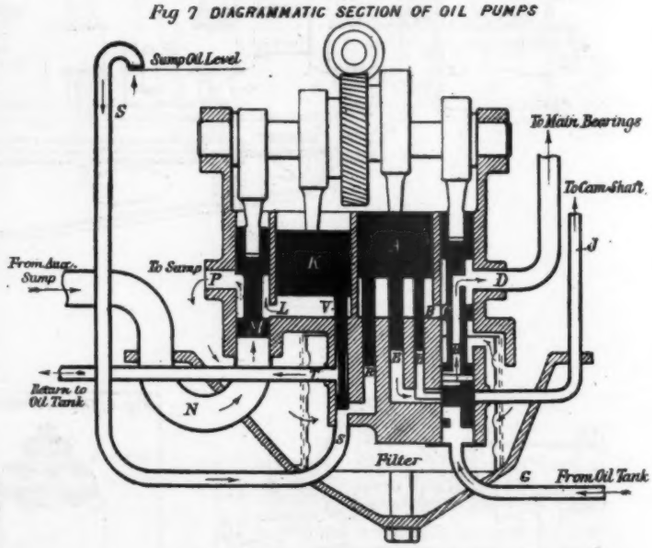


FIG. 8.—SECTIONAL VIEW OF OIL PUMP.

Fig 7 DIAGRAMMATIC SECTION OF OIL PUMPS



their floating cast-iron gudgeon-pin bushes, also follow the usual Mercedes practice and are identically the same as those used on the 160-h.p. engines, and the whole of the camshaft vertical driving shaft, and also the water and oil pumps driving gear, are similar to the 260-h.p. engines.

Crankshaft.—No alteration has been made to the general design of the crankshaft from the standard 160-h.p. type. The leading dimensions, clearances and also resembles in many ways the 260-h.p. type. The usual Mercedes practice of casting the lower half of the main bearing housings integral with the bottom half of the base chamber, and also the method of holding down the cylinders by long bolts which pass through the base chamber top half and secure the two halves of the crank chamber, are adhered to.

Valve Gear.—The single inlet and exhaust valves Mercedes engines. General details of this construction and working of the valve gear are shown in the sketch, Fig. 4, page 603.

Leading Particulars of 160 H.P. and 180 H.P. Mercedes Engines.

	160 h.p.	180 h.p.
Bore	140 mm.	140 mm.
Stroke	160 mm.	160 mm.
Compression ratio ...	4·50 : 1	4·60 : 1
Average brake horse-power and speed	162·5 at 1,400	174 at 1,400
B.M.E.P. (lb. per sq. in.)	102·0 at 1,400	109·1 at 1,400
*Total weight of engine (dry)	618 lb.	635 lb.
Weight per brake horse-power	3·80 lb.	3·65 lb.
Fuel consumption per hour?	94·2 pints	94·83 pints
Fuel consumption per brake horse-power hour	0·58 pints	0·545 pints
Oil consumption per hour	5·0 pints	7·3 pints
Oil consumption per brake horse-power hour	0·031 pints	0·042 pints
Inlet valve opens ...	2 deg. L	T.D.C.
Inlet valve closes ...	35 deg. L	40 deg. L
Exhaust valve opens ...	63 deg. E	40 deg. E
Exhaust valve closes ...	13 deg. L	10 deg. L
Ignition timing (fully advanced)	30 deg. E	30 deg. E
Delivery of water pump	—	41·4 galls. per min.

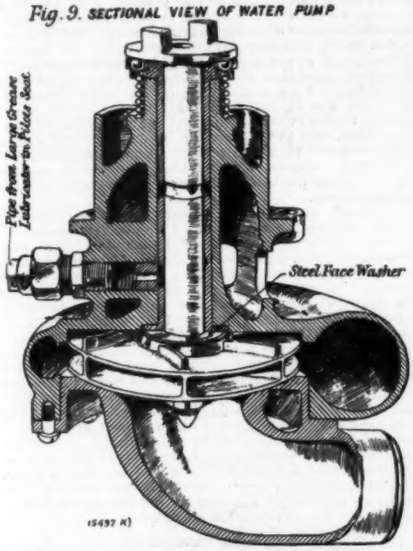
*This weight is weight of engine (dry), excluding propeller hub and exhaust manifold.

It will be noticed that the rocker arms and their spindles are now integral, being machined from steel forgings. The camshaft casing is constructed entirely from malleable iron castings, and the valve rocker spindles work in direct contact with the malleable iron, no bronze bushes being provided as bearings for the rocker arm spindles, and the covers of the camshaft casing form the top portion of the rocker spindle bearings. The rocker spindles are hollow, and are lubricated through two holes drilled radially in the spindles by oil, thrown off the revolving cams into the two holes drilled in the rocker arm carrying the cam roller.

This design of valve gear is undoubtedly a great improvement on the arrangement adopted in the 160-h.p. Mercedes, the construction of which is well known, having the rocker arms working through slots in the camshaft casing, which are provided with felt-packing strips and baffle plates for retaining the oil in the camshaft casing.

Camshaft.—The camshaft is of similar design to the 160-h.p. Mercedes and the casing is supported on long studs which are screwed into the head of each cylinder. With regard to the valve timing, this it will be noticed

Fig. 9. SECTIONAL VIEW OF WATER PUMP



is different from the standard 160-h.p. Mercedes, as shown in the comparative list of leading particulars. The valve lift has been increased from 0·440 in. on the 160-h.p. engines to 0·452 in. Only very minor differences occur in the actual dimensional details of the half-compression gear in the new engine. Details of this mechanism are now well known; the general design is, however, clearly shown in the general arrangement sectional drawing of the engine, Fig. 3.

Carburettors.—No alteration has been made in the design of the twin-jet dual carburettors. Both carburettors are enclosed in a cast aluminium water jacket, which is coupled at the bottom by a water pipe to the delivery pipe of the water pump and at the top to the water jacket of the rear cylinder to the top portion of the water jacket of the carburettors, as shown in Fig. 1.

Each carburettor feeds three cylinders through a branched induction pipe of steel tube, which is lagged with asbestos cord and bound with adhesive tape. The throttles are, of course, interconnected and are operated by a cable and also by a control lever and rod. The float chambers are of ordinary design, but are fitted with separate filters attached to the bottom of each float chamber, which are easily detachable. These filters are provided with needle-valve drain cocks. No compensating arrangement is provided for altitude control.

The bore of the main jets is 1·473 mm. and the bore of the pilot jets 0·558 mm., which is the same as in the 160-h.p. Mercedes carburettors. A semi-diagrammatic sectional view of one of these carburettors is reproduced in Fig. 5, for reference. The air intake to the carburettors is taken through the passage cast in the central portion of the top and bottom halves of the base chamber, which forms an air chamber between the front and rear oil pumps in the lower portion of the bottom half of the base. Air enters the central air chamber through two holes cast in the sides of the chamber and also warm air through a large diameter pipe leading from the central portion of the top half of the crank chamber.

Camshaft Drive.—The method of fixing the camshaft driving bevel at the top end of the vertical shaft, as shown in the sketch, Fig. 6, is unusual. This method is similar to that adopted in the 260-h.p. engines, and is so designed as to allow of a certain amount of vertical adjustment of the bevels. The driving end of the vertical shaft is machined and ground parallel, 21 mm. diameter, and is fitted with a key, which fits in a key-way in the driving bevel; a ground taper on the bottom extension of the bevel, which is split by four saw cuts, and into which screws a ring nut, locks the bevel securely in position on the vertical driving shaft. In the old 160-h.p. Mercedes engines the camshaft driving bevel on the vertical shaft is fixed by two bolts in the split extension of the bevel which is fitted on to a ground taper on the vertical shaft.

Referring to the sketch of the vertical shaft, it will be seen that the bottom end of the shaft is carried on a "Skefko" universal bearing, which is mounted inside a steel sleeve, carried at the rear end of the crank-case, and is driven off the floating bevel gear on the rear end of the crankshaft in the usual way.

Lubrication.—The old 160-h.p. type multiple-plunger oil pump has been replaced by the larger pump, similar in design to the 260-h.p. Mercedes pump. The oil pump is attached to the bottom of the rear oil sump or reservoir, at the rear end of the base chamber. The functions of the oil pump are perhaps most clearly demonstrated in the diagrammatic sectional drawing, Fig. 7, and in the sectional sketch of the pump, Fig. 8. Briefly described, the functions of the oil pump and the system of lubrication may be subdivided into three circuits:—

(*a*) The main-pressure circuit, in which oil is drawn from the main oil sump at the rear of the base chamber and is forced to the main crankshaft journal-bearings and connecting rod-bearings, and also to the camshaft bearings.

Fig. 10. THE NEW AIR-PUMP

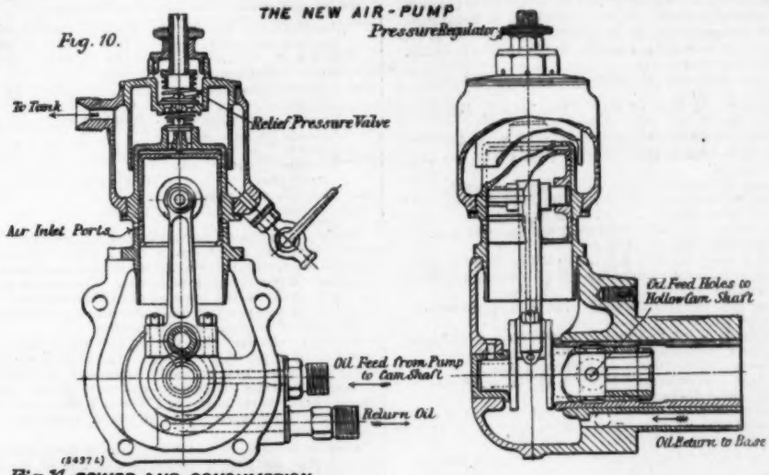


Fig. 14. POWER AND CONSUMPTION CURVES CORRECTED TO 760 M.M.S. BAROMETER. OPEN EXHAUST.

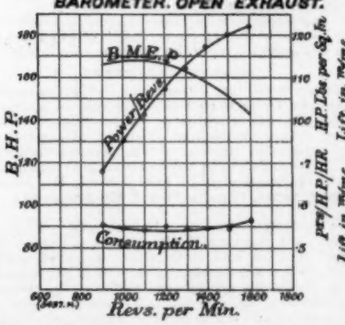
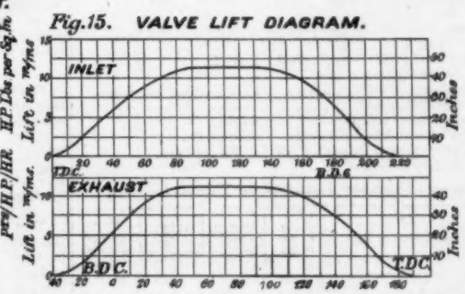


Fig. 15. VALVE LIFT DIAGRAM.



(*b*) The supplementary pressure system, which works in conjunction with the main high-pressure system, in which two auxiliary plungers of the main oil pump draw a small charge of fresh oil from the service oil tank at every stroke of the pump and force the charge into the main circulation system.

(*c*) The suction or scavenger circuit, which supplies the main oil sump from the auxiliary drain sump at the front end of the base chamber, the working oil level being maintained in the rear sump by an auxiliary suction pump which draws off the oil above the oil level through an overflow pipe and returns it to the oil tank.

An oil sight level indicator is provided in the side of the rear oil sump. Full details of the functions and operation of this somewhat complicated oil pump are given in the previous report on the 260-h.p. Mercedes engine.

Ignition.—Two Z.L.6-type Bosch magnetos are fitted at the rear end of the engine and are driven directly off the camshaft vertical driving shaft by bevel gears, as in the 260-h.p. engines. Ignition is by two Bosch 3-point plugs fitted to each cylinder, one on either side of the cylinder below each valve head, and the high-tension cables are carried as usual in fibre tubes attached to the cylinders. The ignition timing is fixed at the same period as in the 160-h.p. engines, *i.e.*, 30 deg. E., and the speed of the magnetos is 1·5 times engine speed. Firing order: 1, 5, 3, 6, 2, 4.

Water Circulating System.—The water pump in the old type 160-h.p. Mercedes engines is situated above the magneto drive, and is driven directly off the vertical camshaft driving shaft. In the 160-h.p. engine the standard 260-h.p. type water pump has been adopted. This is now driven, as in the larger engines, by a dog clutch off the bottom end of the lower vertical shaft, which also drives the oil pump worm-driving shaft, as shown in the sectional arrangement, Fig. 3. The water-pump spindle is provided with a spring-loaded face washer of steel in place of a gland, and the spindle is lubricated by hand, as in the 260-h.p. engines, by a large screw-down grease lubricator accessibly arranged on the pilot's seat. Details of this water pump are clearly shown in the sketch, Fig. 9.

The Air Pump.—This is of new design and is now driven off the front end of the camshaft, as in the 260-h.p. engines. The piston and barrel of the air pump are made of cast-iron, and the piston is operated by a small connecting rod of bronze and a double-webbed crank, as shown in the sectional sketch, Fig. 10. The air pump crankshaft is provided with four serrations which fit into the corresponding splines cut on the inside of the hollow camshaft. The bore of the pump is 40 mm., and the stroke is 40 mm.

Air inlet ports are drilled in the lower portion of the pump barrel and are uncovered by the piston at the bottom of its stroke, and the delivery check-valve is situated in the head of the pump barrel. A regulating valve is provided directly above the check valve, the released air escaping through the centre of the hollow adjusting screw, and also through six small holes drilled radially in the screwed cap which forms the seating of the regulating valve.

A self-contained oil trap is provided by the gun-metal jacket which surrounds the barrel of the air pump. This is fitted with a drain cock as shown in the sketch. The air-pump piston and crankshaft are lubricated by the excess oil in the camshaft casing. The main oil lead from the oil pump to the hollow camshaft is taken through a passage drilled in the crank chamber of the air pump, the oil entering the camshaft through four 5-mm. holes drilled radially in the hollow air pump crankshaft, which register with a groove cut in the inside of its bearing.

ENGINE DATA.

Number and arrangement of cylinders	Six, vertical, separate.
Bore	140 mm. = 5·51 in.
Stroke	160 mm. = 6·30 in.
Stroke/bore ratio	1·142 : 1.
Area of one piston... ...	23·84 sq. in. = 153·9 sq. cm.
Total piston area of engine	143·04 sq. in. = 924 sq. cm.
Stroke volume of one cylinder	150·28 cub. in. = 2,463 cub. cm.
Total stroke volume of engine	901·68 cub. in. = 14,778 cub. cm.
Volume of clearance space	41·3 cub. in. = 676·64 cub. cm.
Compression ratio. Total volume/Clearance volume	4·64 : 1.
Normal brake-horse-power and speed	174 b.h.p. at 1,400 r.p.m.
Piston speed	1,470 ft. per minute.

Brake mean pressure ...	109·1 lb. per sq. in.
Cubic inches of stroke volume per brake horse-power	5·18 cub. in.
Square inches of piston area per brake horse-power	0·823 sq. in.
Brake horse-power per cubic foot of stroke volume	334·0.
Brake horse-power per square foot of piston area	175·0
Direction of rotation of crank and propeller	Anti-clockwise facing propeller.
Lubrication system ...	Forced, multiple plunger pumps.
Oil consumption per hour...	7·3 pints = 8·21 lb.
Oil consumption per brake horse-power	0·642 pint = 0·047 lb.
Oil pressure	20 lb. per sq. in.
Volume of oil carried in base chamber	17 pints.
Number and type of carburettors	One dual Mercedes, twin-jet.
Diameter of chokes ...	0·945 in. = 24 mm.
Bore of main jets	0·058 in. = 1·472 mm.
Bore of pilot jets	0·022 in. = 0·559 mm.
Fuel consumption per hour	94·83 pints = 65·32 lb.
Fuel consumption per brake horse-power	0·545 pint = 0·491 lb.
Inside diameter of induction pipes	2·126 in. = 54 mm.
Number and type of magnetos	Two, Bosch, Z.L.6.
Firing sequence of engine...	1, 5, 3, 6, 2, 4.
Ignition timing (fully advanced)	30 deg. early.
Speed of magnetos ...	1·5 engine speed.
Inlet valve opens	Top dead centre.
Inlet valve closes	40 deg. late.
Diameter of inlet valve (smallest diameter) = d	2·677 in. = 68 mm.
Lift of inlet valve = h ...	0·453 in. = 11·5 mm.
Area of inlet valve opening (w.d.h.)	3·81 sq. in. = 24·58 sq. cm.
Mean gas velocity through inlet valve	153·4 ft. per second.
Clearance of inlet tappet...	0·017 in. = 0·432 mm.
Exhaust valve opens ...	40 deg. early.
Exhaust valve closes ...	10 deg late.
Diameter of exhaust valve (smallest diameter) = d	2·677 in. = 68 mm.
Lift of exhaust valve = h	0·453 in. = 11·5 mm.
Area of exhaust valve opening ($\pi\ d\ h$)	3·81 sq. in. = 24·58 sq. cm.
Clearance of exhaust tappet	0·014 in. = 0·355 mm.
Diameter of inlet and exhaust ports	2·165 in. = 55 mm.
Diameter of water pump inlet	1·692 in. = 43 mm.
Diameter of water pump outlet	1·575 in. = 40 mm.
Ratio of water pump speed to crankshaft speed	1·5 : 1.
Delivery of water pump at normal speed	41·4 gallons per min.
Inlet water temperature ...	64 deg. C.
Outlet water temperature	74 deg. C.
Water jacket capacity of one cylinder	1,280 cub. cm.

GENERAL ANALYSIS OF WEIGHTS.

Description of Part.	No. per Set.	Average Unit Weight.	Weight of Complete Set.	Percentage of Total Weight.
Cylinders (bare)	6	19·25	115·50	17·5
Pistons, complete with rings and gudgeon pins ..	6	6·85	41·10	6·23
Connecting rods, with gudgeon-pin bushes	6	5·00	30·00	4·55
Valves, complete with springs, &c.	12	1·31	15·74	2·39
Crankshaft (bare)	1	70·00	70·00	10·60
Camshaft (bare)	1	7·75	7·75	1·17
Camshaft casing with bearings and covers	1	27·63	27·63	4·18
Valve rockers	12	0·87	10·50	1·59
Half-compression gear(complete)	1	7·00	7·00	1·06
Vertical driving shaft (complete, including casing, oil pump, drive, and floating bevel) ..	1	17·50	17·50	2·66
Base chambers (top half) ..	1	72·25	72·25	10·92
Base chamber (bottom half)	1	100·00	100·00	15·16
Carburettors	one dual	16·75	16·75	2·54
Induction pipes (lagged asbestos)	2	5·00	10·00	1·52
Water pump (complete) ..	1	7·75	7·75	1·17
Oil pump (complete) ..	1	13·25	13·25	2·00
Air pump (complete) ..	1	4·75	4·75	0·72
Magnetos (complete) ..	2	14·00	28·00	4·25
Water piping	—	3·25	3·25	0·49
Propeller hub (complete) ..	1	12·50	12·50	1·90
Ignition wiring (complete)	2	2·00	4·00	0·61
Exhaust manifold	1	13·00	13·00	1·97
Miscellaneous parts ..	—	31·78	31·78	4·82
Total weight of complete engine (dry) (With propeller hub and exhaust manifold)	660 lb.			100·00

Weight of engine complete, dry, including propeller hub and exhaust manifold	Lb. 660·0
Weight per brake horse-power ...	3·79
Weight of exhaust manifold ...	13·0
Weight of oil carried in engine ...	19·125
Weight of fuel and oil per hour ...	93·63
Gross weight of engine in running order, less fuel, oil and tanks, but including cooling system at 0·65 lb. per brake horse-power ...	773·0
Weight per brake horse-power ...	4·44
Gross weight of engine in running order, with fuel, oil and tanks for 6 hours. (Tanks at 10 per cent. weight of fuel and oil)	1,390·3
Weight per brake horse-power ...	8·0

TEST REPORT.

The following is a summary of a report on tests of the 180-h.p. Mercedes engine carried out at the Royal Aircraft Factory, February 6, 1918.

The engine was erected on test bed, and coupled to a Heenan and Froude dynamotor, and power readings taken at various speeds, simultaneous fuel and oil consumption readings being taken. The results of these tests are shown graphically on the curves attached to this report. Fig. 12, page 605.

These curves show the following readings :—

Revolutions per minute	1,300	1,400	1,500
Brake horse-power ...	165	174	180
B.M.E.P.	112	109	105·5
Fuel consumption in pints per brake horse-power	0·540	0·545	0·555
Normal engine speed ...	1,400 r.p.m.		
Average brake horse-power	174		
Average petrol consumption	0·545 pints per b.h.p. hour		
Average oil consumption	0·042	„	„

During a previous test, the engine was run up to 1,700 r.p.m., at which speed 197·5 brake horse-power was recorded, but at this speed the engine was found to be incapable of giving constant power. The engine was run at 1,400 r.p.m. for the purpose of calibrating the output of the water pump, which delivered into a graduated tank at the rate of 41·4 gallons per minute.

Owing to the fact that during the above test it was found to be impossible to tune up the engine, the power developed does not probably represent its best performance, as from other data and tests of the engine a normal brake horse-power of 179·5 at 1,400 r.p.m. and a maximum brake horse-power of 188 at 1,500 r.p.m. has been recorded.

Further details of the 180-h.p. engine are given in the above list of particulars, and a view of one of the latest types of fast enemy scouts, in which this new engine is now used, is shown in the photograph of the Albatross biplane, Fig. 11, page 610.

An interesting stream-line radiator is fitted in the centre section of the top plane, details of which are being issued in a separate report on the Albatross biplane.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new list (No. 54) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, His Majesty's Stationery Office, Imperial House, Kingsway, W.C.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—A meeting of the Northern Centre of the Institution of Locomotive Engineers was held on May 11 at Leeds, when Mr. Gresley, of the Great Northern Railway, delivered his presidential address. In the course of his remarks, Mr. Gresley said that the urgent need of the country was a standardised wagon; since wagons were now ubiquitous no time should be lost in producing a standard. The reduction of the ratio of tare to carrying capacity appealed very strongly to the locomotive engineer. Mr. Gresley touched upon several interesting points in locomotive history, adding that the present-day locomotive was the result of continuous evolution. This evolution was greatly accelerated by superheating. The power of an engine should not, he stated, be judged by its tractive force, but by its capacity to provide steam demanded for its continuous work. He instanced the difference in Mr. Ivatt's Atlantics, one with a small boiler heating surface of 1,450 sq. ft., and a grate area of 24½ sq. ft., and the other with a large boiler, having a heating surface of 2,500 sq. ft. and a grate area of 31 sq. ft. The engines were in every respect identical, therefore the tractive power was equal in each, but the larger boilered Atlantic had proved to be much more powerful as an express engine than the small boilered one; it was able to haul much heavier trains and keep time. On the same work the large boilered engines used less coal; favourable instances were given of the longer life of ample sized boilers. Mr. Gresley further said that engines were approaching their maximum weight and size but were a long way from attaining their maximum power. More power per unit of weight would have to be obtained. The saving which could be made by the introduction of a really satisfactory feed-water heater was second only to the economy which had resulted from superheaters. Grates had shown no marked improvement. Grates could not be much larger but they could be made more efficient. Another consideration was the burning of pulverised fuel, with which a very great intensity of heat could be obtained. There was much scope for development of the carriage and wagon department. But for the war the introduction of steel carriages would have developed to a surprising degree.

THE GERMAN MACHINE TOOL INDUSTRY.

AT the recent general meeting of the Union of German Machine Tool Manufacturers, a report was read which emphasised the vast increase in the production of machine tools during the war, and more especially in the course of 1917. The increase will appear from the following figures: Value of production 1913, 250,000,000 marks; value of production 1914, 325,000,000 marks; value of production 1917, about 800,000,000 marks.

In this connection, however, it must be borne in mind that the price of machine tools, in harmony with the increasing cost of manufacture, has risen about 100 per cent. compared with the price ruling before the war. This brings the aggregate value of last year's production down to a peace value of 400,000,000 marks, but even this is not very far from double the figure of the last year of peace. The report points out that the increased production cannot be looked upon as a lasting one. The question, on the contrary, is one of satisfying a sudden and temporary excessive demand, for which it had been necessary to carry out large and expensive extensions of works. The natural result, now that Government orders have diminished, is the placing upon the open market of a number of machine tools and the replenishment of stocks of both manufacturers and dealers, which stocks had been rapidly cleared out. A distinct difference, however, is to be found between the situation as regards precision machine tools on the one side and the ordinary type of machines on the other, inasmuch as at the end of 1917 there still existed a very satisfactory degree of employment as far as the former were concerned, and even a certain amount of shortage of skilled labour as far as several special machines were concerned. Matters are somewhat different as regards the wholesale production of current types and military machine tools.

Although the tangible shortage of raw materials affects the whole industry and tends to reduce output, all manufacturers are invited to consider from now onward whether a production on the large scale which has lately prevailed is likely to meet with the desired success. Manufacturers are requested not to entertain the hope of carrying out sales based upon extensive foreign orders at cheap prices. Future possibilities are said to rest in the manufacture of high quality machines, and inability on the part of German manufacturers to admit this must, sooner or later, lead to bitter losses. The report also stated that the Allied foreign countries during the year 1917 had in due proportion been supplied with machine tools on terms fully equal to those of the home market. As regards the sale to neutral Powers, a price control, established by the Union of German Machine Tool Manufacturers, had seen to it that German machine tools had not been sold at too low a price. The Union had adopted the principle that machine tools under no circumstance should be sold cheaper to foreign countries than on the home markets.

THE WHOLESALE TRADERS' ASSOCIATION. — The fifteenth annual meeting of this association (for the protection and promotion of the hardware, furnishing and metal industries) was held at the registered offices on April 19, when the Chairman, Major J. H. Cartland, J.P., presided. The chairman, in presenting the balance-sheet and the report of the various departments, stated that the operations of the association had again been fully maintained, and that the members had made extensive use of its various departments, which had afforded them exceptional facilities and assistance in many directions under the present abnormal conditions. It was interesting to note that notwithstanding the war, and the fact that a large number of firms were doing Government work, and therefore were not seeking to open new accounts, the number of status enquiries sent in during the year had reached the enormous total of 63,506, involving a credit of over 5,000,000*l.*, thereby showing that there was still a good general trade being done by the various manufacturers and merchants throughout the country. A large number of orders had been received from foreign and Colonial markets which they were unable to execute at the present time.

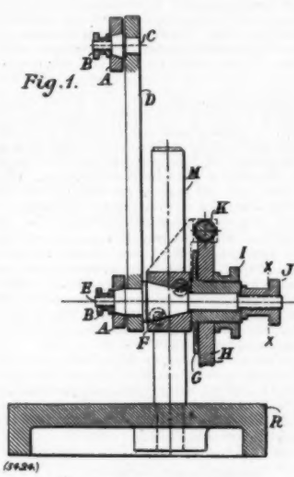
50,000 K.W. TURBO-ELECTRIC GENERATOR.—In the turbine factory of the Allgemeine Electricitäts Gesellschaft, a three-phase turbo generator has just been built having an output of 50,000 kw., corresponding to 75,000 h.p. and running at a speed of 1,000 r.p.m. The terminal pressure of the generator is 7,000 volts, and the exciter pressure 220 volts. One of the principal features of the set is that the entire steam output is developed in a single turbine, and the entire electrical output in a single generator. The weight of the turbine is 250 tons, and the weight of the generator 225 tons. The turbine has ten wheels from 3,400 to 3,800 mm. diameter corresponding to a peripheral speed of from 180 to 220 metres per second. The generator rotor has an external diameter of 2,200 mm. corresponding to a peripheral speed of 115 metres per second. The total length of the rotor of the generator is 9 metres, and the body of the rotor was built up from a large number of steel plates assembled on the shaft instead of being cut from the solid, as in the case of smaller machines built by the A.E.G. The manufacture of this large generator is war time has presented great difficulties to the makers, in view of the scarcity of raw materials. The blading of the turbine, for example, has been prepared without the addition of nickel to the steel, of which there is evidently a great scarcity in Germany. The transport of the turbo-generator to the power station where it will be used, has necessitated the use of a number of special railway wagons, the rotor being carried on a special double bogie car, each bogie having five axles.

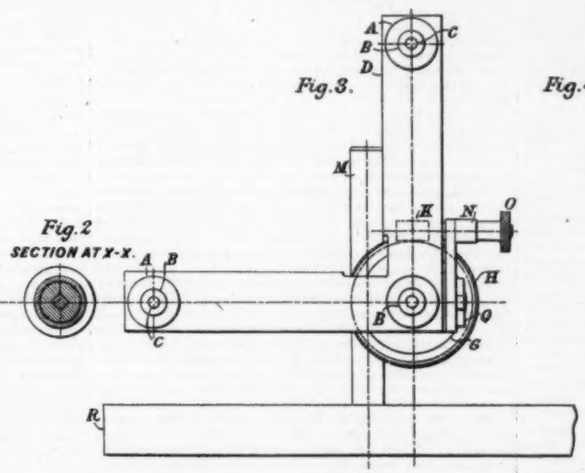
LAYING OUT ANGULAR WORK.

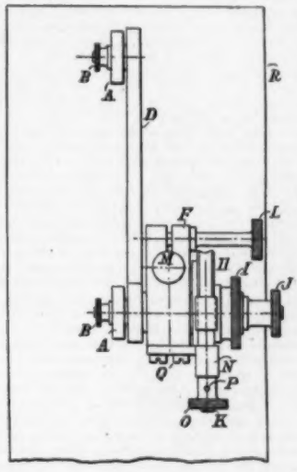
By CLAUDE W. HILL.

IN laying out and checking angular work the protractor is the instrument most commonly used, but the requirement of greater accuracy than is obtainable with this instrument has led to the introduction of the sine bar. The sine bar in its most common form consists of a bar having pins at its extremities placed a definite distance apart. The bar swings on one of these pins, the other end being free, and it is set to any given angle by calculating the length of sine and adjusting the free end of the bar to the distance so found and clamping it in this position. To facilitate the setting, the pins are generally mounted with standard buttons 1 in. in diameter. As the sine of an angle, except for 30 deg., is an incommensurable quantity, it is not possible to lay out the sine with absolute accuracy, and the object of this article is to show the relative accuracy which may be obtained with the different instruments available.

A design of sine bar which has some improvements in detail over those hitherto in use, is shown in the accompanying illustrations, Figs. 1 to 4, the references to which are the following: A, button; B, knurled nut; C, pin; D, sine bar; E, spindle; F, bearing; G, disc clutch; H, worm wheel, 180 teeth; I and J, knurled nuts; K, Worm, 24 threads per inch; L, clamping screw; M, vertical rod; N, bracket to carry







worm; O, knurled head for worm shaft; P, pin; Q, Screws, $\frac{5}{16}$ in. by $\frac{7}{8}$ in. for bracket N; R, base. The construction is as follows: The sine bar D is made with two legs of equal length at right angles to each other. The buttons A are bored conical so as to ensure concentricity and avoidance of side shake when worn in the bore. On slacking the knurled nuts B the buttons may be rotated so that the wear on the circumference may be distributed. The pins C carrying the buttons at the ends of the legs are a force fit in the bar. The bar is a force fit on the spindle E, which has a conical journal running in the piece F which clamps on the vertical rod M, which is a force fit in the base R. The piece G, which forms a friction clutch for the worm adjustment, is a sliding fit on a square on the spindle, as shown in the small cross-sectional view. The worm wheel H turns freely on the piece G. When the knurled nuts I and J are slack the sine bar can be rotated freely for setting quickly to its approximate position. Tightening the nut I brings the worm wheel into gear and the final adjustment can then be made by turning the knurled head O. Tightening the knurled nut J secures the sine bar in position. The instrument is for use with a dial gauge indicator and vernier height gauge, or preferably a micrometer height gauge.

To set to a given angle the centre piece F is clamped at a convenient height. The dial gauge is then adjusted to read zero when passed over the top of the centre button. The height gauge is then adjusted under the dial gauge until the dial reads zero. The height gauge then shows the height from base to top of button. Calling the required angle a, the height from base to top of centre button b, and the distance from centre to centre of the buttons r, the required distance from base to top of outer button will be $b + r \sin a$. The height gauge is set to this height and the dial gauge adjusted over it to read zero. The sine bar is then set so that the dial gauge reads zero when passed over the outer button. After clamping up with the nut J, the position of the buttons should be checked again with the dial gauge. By making the bar with two legs at right angles the one leg can be set to angles greater than 45 deg. by setting the other leg to the complement of the angle.

Protractors being set in degrees and fractions by means of a divided circle, while sine bars are set by laying off the length of sine, the following examples illustrate the relative accuracy obtainable by the two methods, the comparisons being made for an arc having a radius of 5 in. At a radius of 5 in. the lengths of arc are: 1 deg. = 0·0872665 in., 1 minute = 0·00145444 in., and 1 second = 0·0000242407 in. The possible sources of error may be divided into three classes: (*a*) Errors inherent in the instruments, (*b*) personal errors of the operator, and (*c*) limits of error imposed by the degree of fineness in the graduation of the instruments. Class (*a*) may be subdivided into (1) errors due to inaccurate graduation, or (2) due to inaccurate workmanship, wear or illusage. Errors due to (1) may be eliminated by calibrating the instrument and taking out corrections, but errors due to (2) render the instrument useless.

Recently the writer had reasons to suspect the accuracy of a sliding jaw caliper reading thousandths which he was using, and he made the following tests: (*a*) The screw on the sliding jaw was tightened up sufficiently to hold the jaw firmly to the bar, but yet allow it to be moved by the adjusting screw. The instrument was then set to a reading and the width over the jaws measured, the sliding jaw was then moved and brought back to the same reading and the width measured again, the lines on the slider and bar being brought into line each time with the help of a strong magnifying glass. This was done several times, and in each case the widths were different, the difference between the maximum and minimum readings being nearly one thousandth. (*b*) The instrument being set at a reading the screw on the slider was screwed up tight and the width over the jaws measured. The screw was slightly slacked and the width again measured, and this was repeated several times, the screw being slacked off a little each time, but it was not slacked off completely. In this case also the readings were all different, there being a variation of about one thousandth. These tests confirmed the writer's suspicions and showed that the instrument was quite unreliable and useless for fine work. Apparently the sliding jaw was rocking or springing, possibly it had been ill-used.

In several cases recently, in checking fine work which the makers had stated was dead accurate, the writer has found errors of as much as one thousandth. Possibly in these cases the workmen had done the work accurately but had been misled by their measuring instruments.*

It is curious that whereas no one would think of undertaking fine work with say, an electrical instrument a thermometer or a chronometer, without first calibrating the instrument and taking out corrections, the accuracy of length measuring instruments is generally accepted without question. As errors in Class (*a*) either render the instrument useless or else can be eliminated by taking out corrections, they do not affect the comparison between protractors and sine bars. Personal errors, class (*b*), arise from failure of the operator to set the lines on the fixed and sliding portions of the instrument truly in line when setting them, or failure to judge the alignment correctly when reading them.

In setting lines into coincidence with an ordinary magnifying glass an error of $\frac{1}{1000}$ in. is not perceptible, so that the personal error may vary from 0 to at least $\pm \frac{1}{2000}$ in. With some operators it may, of course, be more. Taking a protractor having a divided circle 2 in. diameter the error in length of arc at 5 in. radius may then be 0 to ± 0·001 in., which is equal to an angular error of ± 41·26 seconds. Using the vernier height gauge and assuming the same error, the error would be 0 to $\pm \frac{1}{2000}$ in. in the length of sine and the angular error would vary with the angle, being equal to the error cos a. Thus at 1 deg. the error would be 0 to ± 0·0 02 in., corresponding practically to an angular error of ± 8·25 seconds, and at 45 deg. (which is the maximum angle which requires to be set) it would be 0 to ± 0·000283 in., equal to an angular error of ± 11·67 seconds. Using a micrometer height gauge having a thimble 0·425 in. diameter, each of the 25 divisions around the thimble would be 0·0534 in. wide, and would correspond to an advance of the screw of 0·001 in. An error of $\pm \frac{1}{2000}$ in. in the alignment of the lines on the thimble and hub would then give an error in the measurement of length of ± 0·000003745 in. At 1 deg. the angular error would then be 0 to ± 0·1545 second. At 45 deg. the error in length of arc would be 0 to ± 0·000005296 in. and the angular error 0 to ± 0·2185 second. These figures demonstrate the advantage of the sine bar method over the protractor in reducing the effect of personal error, and they further show that in using the micrometer height gauge in preference to the vernier the personal error becomes quite negligible.

Errors due to the limitations of the instruments class (*c*): The best protractors made for use on the marking-out table are provided with a vernier reading to 5 minutes. The instrument can then be set definitely to any angle in which the number of minutes is a multiple of 5. Thus according to the angle it may be set accurately (neglecting personal error), or it may be as much as 2·5 minutes out, which is equal to a length of arc of 5 in. radius of 0·003635 in. The vernier height gauge can be set to 0·001 in., so that for intermediate dimensions it may be as much as 0·0005 in. out. At 1 deg. this error would be 20·6 seconds. At 45 deg. the error in length of arc would be 0·000707 in., and the corresponding angle 29·1 seconds. The micrometer height gauge provided with a vernier scale on the hub reads to 0·0001 in., so that the maximum errors are one-tenth of those obtained with the vernier height gauge.

In the case of some angles the protractor can be set definitely while the length of sine does not correspond to a definite setting of the height gauge, as is shown in the following examples.

Angle 24 *Deg.* 35 *Min.*—The protractor can be set definitely to this. The length of sine will be 5 × sine 24 deg. 35 min. = 2·08008 in. The nearest setting of the vernier height gauge would be 2·08 in., leaving an error of 0·00008 in., so that the angle actually laid out on the sine bar would be 24 deg. 34 min. 56 seconds+. The nearest setting of the micrometer height gauge would be 2·0801 in., the error being 0·00002 in. and the actual angle would be 24 deg. 35 min. 0·9 seconds+.

Angle 35 *Deg.* 22 *Min.* 30 *Seconds.*—In this case the protractor can only be set at 35 deg. 20 min. or 35 deg.

* It is, of course, absurd to claim dead accuracy, as such a thing could only be obtained by accident. The most experienced and expert firms engaged in precision work do not claim it, but state the number of decimal points, or the limits, within which their work is accurate.

25 min., so that the error is 2 min. 30 seconds, which is equal to 0·003635 in. at 5 in. radius. The length of sine will be 5 × sin 35 deg. 22 min. 30 seconds = 2·894627 in. The nearest setting for the vernier height gauge will be 2·895 in., leaving an error of 0·000373 in., so giving an actual angle of 35 deg. 22 min. 48 seconds+. The nearest setting for the micrometer height gauge will be 2·8946 in., so leaving an error of 0·000027 in. and giving an actual angle of 35 deg. 22 min. 29 seconds.

Errors due to the limitations of the instruments are definite and fixed for any angle, unlike personal error which is uncertain and variable both as to amount and sign, so that the total error may be either the sum or difference of the two errors. It is therefore in the reduction or elimination of personal error, and in the ability to set to angles in which the minutes are not multiples of 5, that the sine bar method possesses its principal advantage over the protractor method of laying out angles.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on May 10 at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper on "*The Times of Sudden Commencement of Magnetic Storms*" was read by Dr. S. Chapman.

The paper is a discussion, from a new standpoint, of the data, collected by Dr. Bauer, for 15 magnetic storms. Maunder's work on the recurrence of magnetic storms at intervals equal to the rotation period of the sun suggests that storms are due to some solar agent transmitted along narrow well-defined streams, issuing from and rotating with the sun. This suggests the view that the relative time of commencement of a storm at different stations depends mainly on the orientation of the latter at the time, relative to the sun, *i.e.*, on the local time at the station. This forms the basis of the classification in the paper.

Dr. Chree said that after hearing the paper he was uncertain whether Dr. Chapman did or did not believe that the figures *proved* anything. He (Dr. Chree) did not think that they did. To deal with a question of a few seconds' difference at different stations, it would, he thought, be desirable to employ not merely a more open time scale, but magnetographs of greater and desirably uniform sensitiveness. When a magnetic change became recognisable depended on the size of the movement and the sensitiveness of the magnetograph. An apparent difference in time between day and night hemispheres would naturally arise if movements tended to be larger in the one than the other. One objection which he had urged against Dr. Bauer's views also applied to the hypothesis considered by Dr. Chapman, viz., that as soon as a disturbance began at any part of the earth's atmosphere it would naturally be propagated by electromagnetic waves to other parts. He was not aware of any direct evidence confirmatory of Dr. Chapman's statement that the atmospheric currents causing the diurnal variation were mainly situated in the comparatively near neighbourhood of the station. Also, even if this were the case, he did not see that any inference could be drawn as to what happened in the case of so different a phenomenon as a "sudden commencement." We did not even know whether the electrical currents causing the two phenomena were at the same level in the atmosphere. "Sudden commencements" were sometimes large, 50 γ or even 100 γ. They were not instantaneous changes, the rise normally seen in horizontal force in ordinary latitudes taking usually four or five minutes to attain its full value, a curious feature being that the high value was generally retained for some time, sometimes, in fact, for several hours, especially at stations in certain latitudes. A consideration of the exact nature of the phenomenon was a desirable prelude to any theorising. On the historical question which Dr. Chapman had raised, as to the discovery of a tendency to "repetition" in magnetic storms, it was very natural for him, as a Greenwich man, to emphasise the really valuable work which Mr. Maunder had done in this connection, but it was only fair to remember the much earlier work of Broun, and the independent work of A. Harvey and the late Professor Birkeland. One reason why a belief in the "repetition" of magnetic storms had advanced so slowly was that sunspot theories had been so often suggested by cranks that they were naturally somewhat suspect. In the case of magnetic disturbances, and Mr. Maunder's Greenwich lists were no exception to the rule, the great majority did not have a "sudden commencement," and opinions as to when the average storm began or ended might differ by several hours. It was thus, in general, impossible to assign an exact value to the interval between two storms. Further what one man called a "storm" another did not, so where one might see a "repetition" another would not. A further complication was the existence of a diurnal period in disturbance data, representing partly statistical imperfections and partly a real natural phenomenon. Dr. Chapman did not seem to realise that the 27-day period was just as manifest in quiet as in disturbed conditions. It was also important to remember that it had presented itself in years like 1913, when sunspots were almost non-existent, just as decisively as in years of many sunspots.

Professor Newall said that when Maunder's results were first brought forward it was felt to be a difficulty that they should involve an almost geometrical recurrence, because, of course, the disturbances on the surface of the sun were travelling with varying periods. When the slide showing the periodic recurrence of certain storms was first shown by Maunder it was noticed that a 1 per cent. difference in the adopted rotation period would change the direction of the lines which indicated coincidence of period to 45 deg. from the vertical. One saw on looking at the slide that there were many cases in which lines at different angles would suit. No one familiar with eclipse phenomena could doubt, however, that something originated in the sun. Many of the streamers sent out from the corona seemed quite straight, and it was difficult to resist the idea that sometimes the earth would be at the other end. Had Dr. Chapman considered the difficulty raised by Kelvin of the necessary energy relations? The energy of the magnetic storm itself might be attributed to something abstracted from the energy of rotation of the earth by the particles after entering the atmosphere.

Father Cortie thought Maunder was the first to connect the 27-day period with the solar streamers. There seemed to him to be a difficulty about these streamers of charged particles. Schuster showed that owing to the mutual repulsion of the charges the stream would be dispersed. He did not think that any particular storm was associated with a particular sunspot, but with a disturbed area of the sun which might extend many degrees. His idea was that the dispersed streamers from the disturbed regions formed clouds of particles and that the earth might enter such a cloud, giving rise to magnetic storms. From the table it seemed to him that there was a slight preponderance of effect on the right side relative to Greenwich, *i.e.*, over the Pacific Ocean. Would the presence of a large expanse of water be likely to affect the phenomena?

Mr. T. Smith asked why the times of sudden commencement were chosen. He would imagine that similar time relationships would hold for any prominent feature. One would normally expect greater irregularities just at the beginning of the storm than when it was well under way. When it was known that a storm had commenced, wide scale runs could be started and measurements made on some subsequent outstanding feature.

A member asked what irregularities might be due to lag in the different instruments used in the different observations.

Professor Lees said that when Dr. Chree first brought the matter before the Society he had set some of his students to work out the correlation factor of Bauer's figures. The factor was so low that there was evidently no basis whatever for Bauer's theory.

Dr. Chapman, in reply, said he did not put any reliance on the actual figures given in the paper. The observational error was too great. It was the method of treating the observations that he thought was of importance. He thought diurnal variations were produced at lower levels of the atmosphere than storms. By "near neighbourhood" he meant within about 1,000 kilometres or so. He did not think Maunder connected the storm with actual sunspots, but rather with disturbed regions Of course, any proper motion of the disturbed region on the sun would alter the period in particular cases; but in examining a long series it was best to take the synodic period, since the others would be distributed on either side of this. He had not yet gone into the energy question, but did not think that this would present any insuperable difficulties. He did not think the streams would diffuse very much. He thought they consisted of particles. They did not necessarily proceed radially from the sun, but might emerge in all directions from radial to tangential. This, however, would not seriously affect the time taken to pass across the earth. There was a definite reason for choosing the commencement times of the storms. When the storm was under way the magnetic state of the earth was fluctuating, and it was difficult to recognise accurately particular features. There was certainly a lag in the measurements which differed in different instruments; but the effect of this was greatly reduced in the present method of grouping the observations, since the same instrument on different occasions contributed results to different groups. In this respect the methods had a great advantage over classification on a geographical basis, in which case any instrument was always in the same group.

A paper, entitled "*The Entropy of a Metal*," was read by Dr. H. S. Allen. An expression for the entropy of 1 gram atom of a substance in the solid state has been given by Ratnowsky. In a communication to the Physical Society in 1916 the author gave the correct form of the approximation required for high values of the absolute temperature in terms of Bernoulli's numbers. The data required for testing the formula have been supplied in a recent paper by Lewis and Gibson, who have given values for the entropy of the elements under the condition of constant volume, and also under constant pressure. These values were deduced from observations on the specific heat assuming the truth of the heat theorem of Nernst, that the entropy of every actual substance in the pure state is zero at the absolute zero of temperature. It is found that the formula of Ratnowsky gives values for the entropy of a solid in very close agreement with those obtained by Lewis and Gibson. The hypotheses assumed in the theory of Ratnowsky are discussed, and the conclusion is drawn that these are probably justified as being at least approximately true.

A paper, entitled "*On Tracing Rays through an Optical System*," was read by Mr. T. Smith.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The secretary of this institution informs us that the scrutineers have declared the candidates mentioned below to be duly elected. President, Mr. C. H. Wordingham; vice-presidents, Mr. W. A. Chamen and Mr. R. A. Chattock; hon. treasurer, Mr. J. E. Kingsbury; ordinary members of council: Mr. H. W. Clothier, Mr. D. N. Dunlop, Sir R. A. Hadfield, Bart., F.R.S., Professor E. W. Marchant, D.Sc., Mr. C. C. Paterson, O.B.E., and Mr. J. Sayers.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Work Resumed.—While in some of the Sheffield industries there was no cessation of operations at Whitsuntide in others the holiday lasted practically a week. But this was not in accord with previous arrangements. The workers should have started on Wednesday last week, but a considerable proportion of them failed to turn up at the specified time, and it was Monday this week before the city's industrial machine was in full working order again.

Electric Melting.—Messrs. Hadfields, Limited, who were among the pioneers of electric melting both for steel and castings, are about to add another furnace of the Heroult type to their installation. It is stated that they have also placed an order for one of the Greaves-Etchells type. Other firms, too, are going in for more open hearth furnaces, the intention in some cases being to use them as feeders of electric furnaces.

Iron and Steel.—The heavy branches of the steel trade continue to enjoy great activity. In addition to material for war purposes, and that demanded by the shipbuilding boom, makers have a considerable amount of work on hand for rolling mills, forging presses and other plant for steel works. There is no appreciable change in the state of affairs in the crucible steel section. It is being kept fairly busy, but there is a certain slackness apparent, compared with the activity which was formerly experienced. This fact is principally due to the very tight restrictions which are maintained on overseas trade. The steel for munitions requirements is being gradually increased in volume, and with this upward tendency happens to come along a rationing scheme which should make matters much more satisfactory for users of steel for tools, &c., than would be the case without it. Under the scheme, the balance of steel remaining after all purely war needs have been met, becomes available for equitable distribution among the class of users referred to.

South Yorkshire Coal.—The position in the coal trade is very difficult. Included in a very big demand for best steams, is a greater call for supplies from France and Italy, and this on top of a reduced output consequent upon the withdrawal of men from the pits for the Army, is naturally causing a pronounced shortage. Cobbles, nuts and slack are all still very difficult to obtain, practically the whole of the output going away on contract account. In household sorts there is a marked shortage, and one which is wholly out of keeping with the time of the year. Merchants have many long-standing orders to meet, and the supplies coming forward are quite inadequate to satisfy them. The Controller tightens rather than relaxes his pressure, and the public must prepare to experience greatly reduced supplies for next winter. Cokes are scarce, with prices at the maximum. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.* per ton at the pit.

THE NORWEGIAN IRON AND STEEL INDUSTRY.—Much activity prevails within the Norwegian iron and steel industry, and more comprehensive plans will no doubt be furthered in due course. The Näs Ironworks are on the point of being largely extended with a view to adopting electric steel smelting. This would appear to be planned on the basis of a new and, it would seem, very advantageous method; a smaller power station is being built for experimental working and the completion of the tests. Great confidence appears to prevail with regard to the final results. The Christiania Steel Works, whose new capital has been fully subscribed, are building a plate rolling mill having a capacity of 30,000 tons per annum. It is proposed in course of time to erect three open-hearth furnaces, one only being put down in the meanwhile. The Hamar Iron Foundry are erecting a section and rod rolling mill.

LARGE GERMAN WAR PROFITS.—Balance sheets showing large and increasing profits for last year continue to be forthcoming, a fact which also refers to several Silesian concerns. Thus the Upper Silesian Iron Industry Company, Gleiwitz, shows the following net profits for the last five years:—1913, 571,119 marks; 1914, 239,171 marks; 1915, 1,993,417 marks; 1916, 3,312,077 marks; 1917, 4,461,002 marks; the dividends for the five years in question being respectively 0 per cent., 3 per cent., 6 per cent., 10 per cent., 14 per cent., the writings-off having during the same period risen from 2,000,000 marks to 5,000,000 marks, in addition to which the Bibiella installations have been entirely written-off. At the Juliane Hütte, a new blast furnace has been erected and at the Baildon Hütte a new plate rolling mill; whilst at Königsschuld a couple of new shops have been built. The share capital is 28,000,000 marks and debentures amount to 15,330,000 marks. The workmen number 10,237, and wages and war profit tax have risen from 19,990,000 marks in 1916 to 31,600,000 marks for 1917. The Silesia Ironworks, which are also fully employed in all branches, pay 21 per cent. for last year against 18 per cent. for the previous year. The Baer and Stein Metal Goods Company, Berlin, earned net profits for 1917 amounting to 1,129,316 marks against 664,246 marks for 1916, the dividends for the two years being respectively 30 per cent. and 25 per cent. The company continues to be employed to the fullest of its capacity with army contracts.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Probably nothing could excel the activity which still goes on in every steel-making establishment in the district, nor, in the light of present circumstances, is there the slightest chance of any abatement for some considerable time to come. For one thing, the demands of the shipbuilding yards are incessant, and it is only by the utmost exertion that these can be satisfactorily met. In some quarters this is more easily managed than in others, with the result that at the moment a certain proportion of the output is available for the use of ordinary mercantile consumers who are not engaged on Government contracts or upon work which might, strictly speaking, be termed of national importance. At the same time, although export is still "off," slightly increased shipments of finished steel to France have been possible. Light sectional material is in constant request and, of course, ship and boiler plates.

Malleable Iron Trade.—The turning out of large quantities of material, both iron and steel, for purely Government purposes absorbs the whole time and attention of malleable iron makers, and the pressure is most intense. An exceptionally heavy demand exists for small sections, the output, in consequence, on a very high level. Rumour presupposes an early fall in the price of steel, but as yet no definite pronouncement can be made.

Scotch Pig-Iron Trade.—So far as is compatible with the many drawbacks against which manufacturers have to contend at the present time, maximum outputs of pig-iron are being well maintained and orders are so well booked up that smelters are most reluctantly compelled to turn a deaf ear to the solicitations of many consumers who would gladly do a deal with them. So long, however, as producers find a difficulty in supplying more than a percentage of the desired material to each customer there is little chance of any of the output being available for the use of outsiders, no matter what their necessity. Every grade is in strong demand, with hematite still leading, the continued activity in the steel works in the West of Scotland area being such that every ton produced is promptly absorbed on Government account. Little or no export is being put through. No change in price has yet taken place.

Holidays in Prospect.—The announcement by the Ministry of Munitions that, so far as is possible, the customary holidays for industrial workers in Scotland shall take place at the usual time and for the usual period has been received with considerable satisfaction by those most intimately concerned, the upheaval of the past two summers being still fresh in the memory of everyone. During the next six weeks everything possible will be done in the Glasgow district to speed up the output of munitions of all description, and the engineering and shipbuilding material required for the many Government contracts on hand so that delivery may be ensured before the various works close down for the Fair Holidays. Efficient production demands a certain period of rest and recreation for those employed upon it, besides which, machinery and plant running continuously requires regular overhauling, which is only possible when holidays are in progress, and the recognition of these facts tends to a better understanding all round.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is much activity in all branches of the Cleveland pig-iron trade. By no means the least contribution to the better state of affairs is the much improved facilities for transport of iron. With the better and still increasing supply of trucks substantial parcels of iron are being railed to Scotland. The commencement of the issue of June allocations of foundry iron have brought in home buyers, and deliveries over the incoming month now promise to be heavy. All the Scottish foundries are very busy and are making big demand on pig-iron output, the supply of which, however, is very plentiful. There is no abatement in the home demand for forge iron, though recent deliveries have been such as to enable consumers to accumulate a little stock. It is very gratifying to hear decidedly better accounts of export trade. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are 114*s.* and No. 1 is 119*s.*

Hematite Iron.—The somewhat sudden improvement in the tonnage situation has brought forward demand for hematite iron for export under existing licences, but most of the make has been distributed to home steel-makers, because of the absence of facilities for shipment, and now that vessels have become available iron is not easily obtained for loading. The situation will be pretty quickly adjusted. Nos. 1, 2 and 3 East Coast brands are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—Great activity continues to characterise all branches of the finished iron and steel industry. Output, though huge, and still steadily expanding, fails to keep pace with the enormous demands. Manufacturers are still almost entirely occupied on Government work, and in the supply of shipbuilding material. Quotations, all round, are strong. To home customers, common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.* Prices for export are not fixed, but approximately they are 40*s.* to 60*s.* above home quotations.

Coke.—As was anticipated, supply of coke has become insufficient fully to cope with the heavy demand. The scarcity is not very serious, but some inconvenience is being experienced in consequence of shortage. For home use foundry quality is 38*s.*; average blast-furnace kind, 33*s.* at the ovens; and low phosphorus sorts 35*s.* 6*d.* at the ovens. For shipment to neutrals foundry and furnace coke are quoted 55*s.* and upward, and little business is passing.

NOTES FROM THE SOUTH-WEST

CARDIFF, Wednesday.

The Local Markets.—Business on the markets has been very quiet since the Whitsuntide holidays last week. The miners were very dilatory in returning to work, and throughout last week there was a good deal of absenteeism. Moreover, the strikes in Monmouthshire have accentuated the shortage, with the result that the output is totally inadequate to meet immediate requirements. A determination has been expressed on the market to ask higher figures for neutral shipments, but for destinations other than those under the control of the authorities there has been no coal available, and accordingly none but scheduled prices have been realised. It is understood that the Coal Controller is taking action with a view to a revision of these scheduled prices, and it is regarded as extremely likely that on the information that is now to be supplied to him, the Controller will agree to such an increase in the price of coal as will make the control scheme self-supporting. Fortunately there has been no cessation of work in the steam coal areas, with the result that there is a better supply of the coal required for the most essential purposes.

Newport.—Business in Monmouthshire coals has been brought almost to a standstill by the strikes in the Eastern, Western and Rhymney Valleys. The result has been an enormous reduction in output, and a complete dislocation of trade. The outlook for the immediate future is very uncertain, as it is not yet known whether the men will be induced to return to work.

Unrest in the Coalfield.—A most regrettable situation now obtains in the Welsh coalfield. The storm centre is in Monmouthshire, at the Tredegar Collieries. Here the men came out suddenly because the management refused to meet a deputation from what is known as the Combine Committee in order to adjust a grievance at one of the collieries—that of Markham. When the Standing Joint Disputes Committee of the Coal Board met last Friday an agreement was arrived at between the owners and workmen's representatives and terms agreed upon under which the men were to resume work. At a meeting of the Executive Council of the South Wales Miners' Federation held on Saturday these terms were unanimously approved by all the members of the council, including even the most extreme section whose view was that the men should now resume work as they had secured all that they came out to secure. Members from the council were sent to Tredegar on Sunday, but, contrary to all anticipations, the men bluntly refused to act on the advice of their leaders. Moreover, emissaries were sent around to induce other collieries to join in a sympathetic strike, and they succeeded so well that by yesterday upwards of 35,000 men were idle. A special meeting of the Executive Council was held yesterday and urgent telephonic and telegraphic messages were received from the Coal Controller, who pointed out that the men were "jeopardising the chances of their fellows in the trenches." Deputations from both the owners and workmen's representatives were hurriedly summoned to London to-day, but there has been no improvement in the situation, for although at some of the collieries the men to-day went back to work, the strike movement spread to other collieries, so that if anything more men are idle to-day than was the case yesterday. A special conference of delegates representing the whole of the coalfield has been convened to take place at Cardiff to-morrow, and all now depends on what attitude will be taken by the delegates at this conference. Altogether the position is one which causes grave concern, as the men are acting in defiance not only of the owners and the Coal Controller, but also of their own leaders.

Restricted Supplies of House Coal.—The details of the new scheme for the restriction of the supply of coal for household consumption have now been issued by the South Wales Coal and Coke Supplies Committee. In April last the committee decided that they would be unable to continue the operation owing to altered conditions in the coal trade. The reduction in outputs due to the comb-out of a large number of workmen for military service, and the increasing requirements of the Allies, munition works, &c., made it impossible for the committee to instruct colliery companies to supply certain fixed quantities of house coal per month, and accordingly a new scheme of distribution was prepared involving restrictions on consumption. It is this scheme which has received the approval of the Controller of Coal Mines, and is now made immediately operative. Its main features are a reduction at present of 10 per cent. in the quantity supplied by the colliery companies below that supplied in May, 1915, and a reduction in June of 20 per cent. on the quantity supplied in June, 1915. But the scheme provides the conditions, also, under which supplies are to be made by factors, merchants and retail merchants, and these specify: (1) That the supplies by merchants to basketmen must be reduced by 20 per cent. during June; (2) that merchants must not deliver more than 1 ton per calendar month to any house; (3) that coals delivered in bags or baskets must not exceed 5 cwt. in any week to the same householder; and (4) that colliery companies must not supply a truck of coal to any private individual who is not a coal merchant, without the sanction of the committee. The final clause of the new scheme provides that merchants who obtained their supplies from districts other than Monmouthshire and South Wales prior to the Coal Reorganisation Scheme, are entitled to the monthly quantity which was allocated to them by the Committee at the latter end of 1917, and the colliery companies are instructed to supply such quantities subject to the reductions indicated.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, June 1, 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following paper will be open for discussion: "A System of Storing and Filling Small Coal, with Remarks upon the Prevention of Spontaneous Heating in Coal-heaps," by Mr. John Morison [Trans.Inst.M.E., 1918, vol. lv., page 76]. The following paper will be read or taken as read: "Notes on Overhead Kœpe Winding Plant, Plenmeller Colliery, Haltwhistle, Northumberland," by Mr. George Raw.

THE RÖNTGEN SOCIETY.—Tuesday, June 4, at 8.15 p.m., at the Royal Society of Arts, 18, John-street, Strand, W.C. Paper and demonstration by Mr. N. E. Luboshey, "An Investigation of the Photographic Action of X-Rays."

THE INSTITUTION OF GAS ENGINEERS.—Tuesday and Wednesday, June 4 and 5, the annual general meeting will be held at the Institution of Civil Engineers, Great George-street, Westminster. The President, the Right Hon. Lord Moulton, G.B.E., F.R.S., will take the chair each day at 10.30 a.m.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, June 7, at 5.30 p.m., a discourse will be delivered by Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. The subject will be "The Romance of Petroleum." Afternoon Lectures at 3 p.m.:—On Tuesday, June 4: Sir Arthur Newbolt, D.Litt., on "The Poetry of Thomas Hardy: The Shorter Poems" (Lecture II). On Thursday, June 6: Lieutenant-Colonel Sir Francis Younghusband, K.C.S.I., K.C.I.E., on "The Abode of Snow: Its Appearance, Inhabitants and History" (Lecture III). On Saturday, June 8: Professor Charles J. Patten, M.D., Sc.D., on "Problems in Bird Migration" (Lecture III).

TYPE METAL RETURNS ORDER.—An Order of the Ministry of Munitions, dated May 28, provides that all persons having or controlling type metal exceeding 1 cwt. in amount must, within 28 days, make a return thereof to the Controller, Non-Ferrous Materials Supply, Ministry of Munitions, MS/ES, 8, Northumberland-avenue, London, W.C. 2, distinguishing between (*a*) type in case, including standard matter in chase and paper, on boards and matter awaiting distribution; (*b*) spacing material, including quads, quotations, metal furniture and leads; (*c*) electric plates and blocks; (*d*) stereo plates, metal and blocks; (*e*) linotype metal; (*f*) monotype metal. All applications in regard to the Order should be addressed to the Controller and marked "Type metal."

THE "SHIPPING WORLD" YEAR BOOK.—The "Shipping World Year Book" of which a copy has been sent us, is edited by Major Jones, and is published at the price of 10*s.* net by *The Shipping World*, Effingham House, Arundel-street, Strand, W.C. 2. It contains over 2,000 pages of information on all the British, colonial and foreign ports, the information covering the situation of the port, the class of trade in imports and exports, the accommodation available, charges, pilotage, and the names of the officials. About half of the book is taken up by the customs tariffs of all nations. Like in the former editions, a carefully prepared map of the world, specially prepared by Mr. J. G. Bartholomew, F.R.G.S., is inserted. The editors are to be congratulated for having brought out the present edition in the difficult times now ruling.

THE WILBUR WRIGHT MEMORIAL LECTURE.—The Wilbur Wright Memorial Lecture will be delivered in the Central Hall, Westminster, on Tuesday, June 25, at 8 p.m., by Dr. W. F. Durand, chairman of the American Advisory Committee for Aeronautics and Scientific Attaché to the American Aviation Mission in Europe. His subject will be "Some Outstanding Problems in Aeronautics." The Wilbur Wright lecture is given out of the proceeds of an endowment founded in memory of the late Mr. Wilbur Wright, the founder of modern flying, and the premium this year has been awarded by the Aeronautical Society of Great Britain, which administers the fund, to Dr. W. F. Durand. The entry of the United States of America into the war could not be more suitably celebrated than by recognising the great services of the late Mr. Wilbur Wright to aeronautics, and the selection of Dr. Durand, not only on account of his many qualifications, but also on account of the great nation to which he belongs, is a singularly happy one. It is likely that there will be a great many applications for tickets, and those desiring them should apply at the earliest possible opportunity to the Secretary of the Aeronautical Society of Great Britain, 7, Albemarle-street, Piccadilly, W. 1.

180-H.P. MERCEDES ENGINE AND ALBATROSS SCOUT BIPLANE.

(*For Description, see Page* 603.)

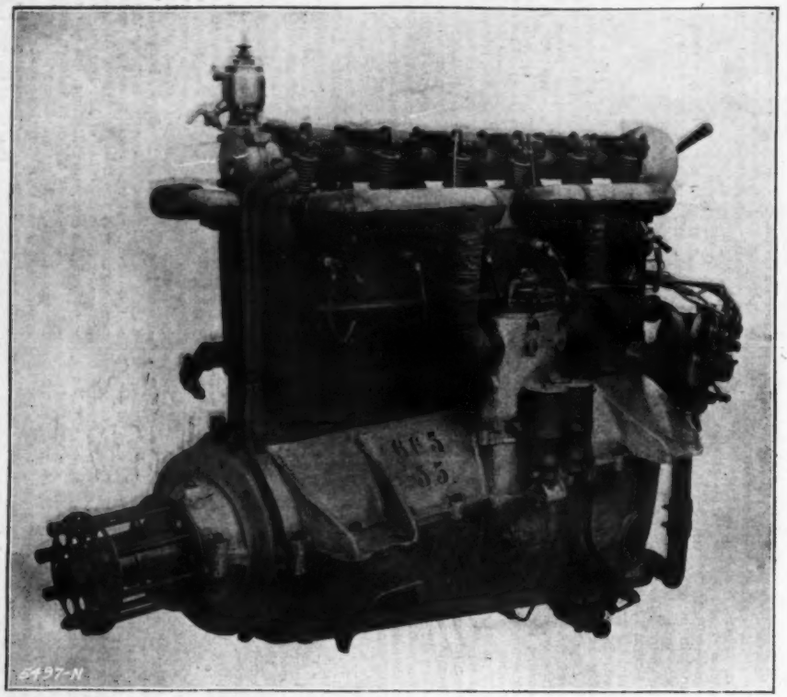


FIG. 1.

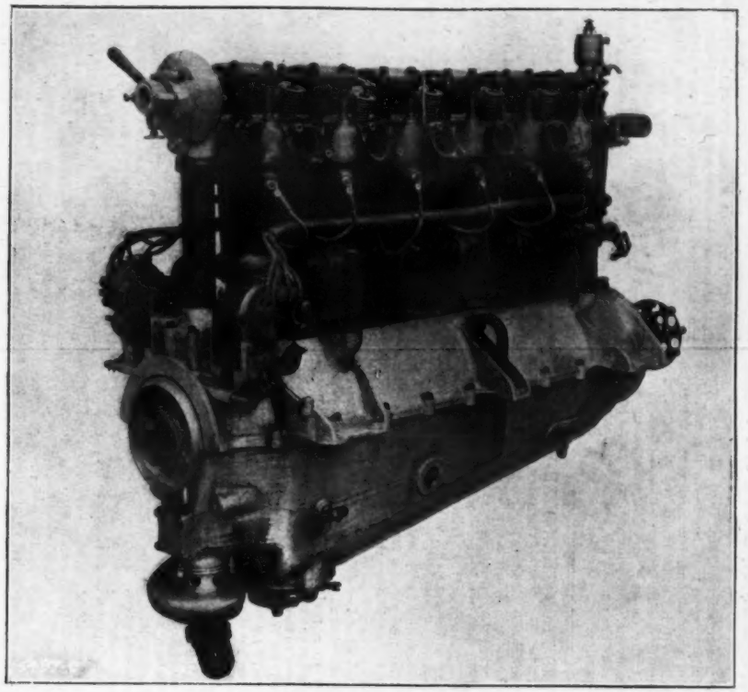


FIG. 2.

WEEK-END RAILWAY TICKETS FOR MUNITION WORKERS.—The President of the Board of Trade has been in communication with the Minister of Munitions on the subject of special cheap travelling facilities, and regrets that it is necessary, owing to the pressure on the railways, that the limited number of cheap week-end tickets which have been issued to employees of controlled establishments must be withdrawn.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—The Engineering Standards Committee, which as is well known was formed in 1901 by the leading engineering institutions, has now become incorporated under the Companies Acts, 1908–1917, the word "Limited" being omitted by licence of the Board of Trade. The committee, therefore, becomes now a corporate body with a legal entity, and is thus enabled to maintain its position in regard to its brand, which has been largely used in a number of the British Standard specifications. The wider use of the brand by manufacturers generally who are working to the British standards, should be of material advantage to the British engineering industry throughout the world. The good work that the committee has done during the past seventeen years, which is such a monument to its founder, the late Sir John Wolfe Barry, K.C.B., F.R.S., and its acknowledged position in the engineering world, makes its incorporation a logical sequence in its development.

FIG. 11.

5,000-TON REINFORCED CONCRETE SHIP.—The 5,000-ton concrete ship **Faith**, referred to on page 281 *ante*, was afloat on May 18, outside the bay of San Francisco, in a final trial trip. Experts declared the seaworthiness of the vessel to be abundantly proved. Several United States officials were aboard. They asked for a re-trial test before selecting the site for the 10,000,000 dollar Government plant to be erected on the Pacific Coast for the immediate construction of a number of concrete steamers. Anticipating the Faith's triumph, several Californian cities are competing for plants. One city offers 100,000 dollars and an entire harbour on which it recently expended 5,000,000 dollars. Another city offers 90 acres with a 2-mile frontage.

YEAR BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES.—We have received from Messrs. Charles Griffin and Co., Limited, Exeter-street, Strand, W.C. 2, the thirty-fourth annual issue of their "Year Book of the Scientific and Learned Societies of Great Britain and Ireland." It gives the name and address of each society, the names of the officers, the dates of the meetings, membership and the titles of the papers read during the last sessions. The book is divided into 15 sections, covering general science, astronomy, mathematics, physics, chemistry, photography, geography, mechanical science, agriculture, naval and military science, law, medicine, &c. It is carefully got up and indexed. It is issued at the price of 9*s*.

AGENTS FOR "ENGINEERING."

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With a Two-Page Plate of the NEW TROLLHÄTTA CANAL; DETAILS OF FLIGHT OF LOCKS AT TROLLHÄTT AN

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 609.

ENGINEERING.

FRIDAY, MAY 31, 1918.

THE ECONOMICS OF STEEL DUMPING.

THERE is a growing volume of opinion against dumping, but the real economics of the practice as pursued by Germany is by no means well understood. It is of vital importance that the subject should be closely studied and definitely tackled. German dumping is not the casual selling of surplus goods below cost price, but real economic war, subsidised by Government and organised by great syndicates with the deliberate intention of destroying competitive trades and securing monopolies for German industries. This policy has not only been specially directed against British trade, but it has had the widest possible scope in this country by virtue of our peculiar fiscal system. Largely as a result of German dumping upon our home market, and those of our Colonies and present Allies, our iron and steel trades made very little headway for many years. The Germans, after a late start, and in spite of poorer natural resources and shipping accommodation, much smaller colonies and less investments in foreign railways and other undertakings requiring iron and steel, actually beat us in iron and steel exports before the war.

The Paris Economic Conference of 1916 recommended the Allied Powers to adopt measures for the prevention of enemy dumping after the war, but did not specify any particular measures for the future. Our British Departmental Committee on the Iron and Steel Trades has recommended anti-dumping legislation and the imposition of maximum, general, and minimum tariffs on imports. The committee presided over by Lord Balfour of Burleigh, in its comprehensive report on trade and fiscal policy in general, states that it understands dumping to be the sale of goods in a particular market at prices lower than those at which the goods are offered in the country of manufacture, but it does not think it necessary, or expedient, to establish a comprehensive tariff scheme. Nevertheless, the majority conclude that "the producers in this country are entitled to require from the Government that they should be protected in their home market against dumping," and recommends that "action be taken" on the lines, though not necessarily in the form, "adopted in Canada." The Dominion Tariff provides, briefly, that articles imported into Canada of a class made in Canada, and at a price to the importer less than the "fair market value" of the same article when sold for home consumption in the country of origin, shall in addition to the ordinary import duties levied be subject to a tariff, or special dumping duty, equal to the difference between the said selling price of the article for export and the said fair value thereof for home consumption in the country of production. The Canadian manufacturers are generally relied upon to furnish the information necessary for the levying of the special dumping tariff, and this is said to work satisfactorily. There is general belief that the law has had a deterrent effect upon foreign dumping, and has been of material assistance to the Dominion's industries. At all events, the Canadian iron and steel trades are rapidly growing. The recommendations of the majority of the Balfour Committee are a distinct advance upon anything previously advanced by any authoritative body; but there is a strong minority report against the imposition of anything beyond a 10 per cent. tariff, which, it is contended, would give the home manufacturer "security against unfair competition." This hardly squares with the fact that German steel has been exported and sold in this country 33 per cent. below home prices. We fear that in the highest quarters there is still failure to understand the principles, objects, and effects of German dumping. We say German dumping because Germany is the only country that has adopted on a large scale this particular form of State and syndicate subsidised exportation for the same set purpose.

To begin with, dumping means selling goods abroad at lower prices than at home. German dumping means persistently selling goods abroad below actual, or natural, cost of production until the industries of the country that is thus dumped upon are ruined and the Germans can effect a monopoly and then charge what they like. Now if we were simply a nation of consumers the more dumped goods we got the better off we should be, for we should get more for our money. But we may be quite sure that if we were only a nation of consumers the Germans would not offer us dumped goods. They would have no interest in so doing. It is because we have certain productive trades which they wish to damage or ruin that they offer this kind of competition. They stoop to conquer. The supreme point in the problem, which we ought to keep clearly in view, is that primarily we are a nation of producers. It is only by producing things and selling them that we are enabled to become consumers. If our productive industries go we are ruined. The question of consuming, or of spending money, or of how much we get for our money, is only a secondary one compared with the importance of producing. The German dumping policy was deliberately aimed at the destruction of competitive —especially British—industries. The Germans did not subsidise their goods and offer them below cost of production out of love for us as consumers, but to beat us as producers and traders. That was the object. How well on the way to success it was may be evidenced by the fact that our iron and steel trades were rendered all but stagnant at a time when the world's demand was growing enormously —it was almost impossible to obtain new capital to extend and modernise our works—whereas the iron and steel industries of Germany were advancing almost by leaps and bounds. In fifteen years German iron and steel exports increased by 500 per cent. Ours increased by less than 50 per cent., and even this was considerably offset by a big increase of imports that should have been produced in our own works. We were being beaten first in one line and then in another, first in one market and then in another, by German dumping. At the pre-war rate of progress Germany, well inside of another twenty years, would have nearly swept our products off the world's markets. Prior to the adoption of the German dumping policy we were exporting five times as much iron and steel as our rivals, as we were quite entitled to by reason of our great dependence on manufactured exports to balance abnormal food imports, and in consideration of our huge Colonial possessions and capital investments in foreign railways and similar undertakings needing steel goods. But in the last twelve months before the war the Germans exported over 1,000,000 tons more than we did, and they were going rapidly ahead while we were only marking time.

To carry out the dumping policy it was necessary for the Germans to be both protected and organised. Dumping was not allowed in the German market. Imports had to carry the handicapping weight of a German tariff before they could enter that market. Thus the home producers were sheltered from outside competition. The home market was reserved for them and they were encouraged to increase their capacity. Then the syndicates set to work to

capture foreign markets, and they conveniently found the British market open and free, and our Government, municipalities, railway companies, and traders in general quite willing to accept cheap German products regardless of the welfare of our home industries. Every important material and article of steel production in Germany was syndicated, from iron ore to sewing machines and wire nails. A standard home price was fixed for a certain material, say coal, or pig-iron, but upon every ton estimated as used by the manufacturers in producing goods for export a rebate was allowed, with extra rebates for the capture of trade in any particular market. These rebates sometimes amounted to as much as one-third the natural cost of production. Besides that, the Government carried the goods for export at half the ordinary rates on its railways, and it subsidised the vessels taking the goods abroad. No wonder British producers were frequently undersold! Moreover, the Germans were guilty of much false marking and the piracy of trade marks and names. Protected from outside competition by tariffs, assured of bounties and subsidies on his exports, and with a free market in one great country, the German manufacturer could go on in confidence adding to the capacity of his works, increasing employment and trade. Such was dumping, as practised by Germany. The need for its prevention in the future, as far as it is possible to prevent it, and by almost any and every available means, should be clear and indisputable.

Some people contend that very little of a practical nature can be done to prevent dumping; that if we and our Allies and Colonies attempt to penalise German goods in those markets we can control, the Germans will export all the more to neutral markets and beat us there. It may be conceded that nothing we can do will stop the Germans subsidising their products if they are disposed to do so; but it is certain that tariffs would make it more difficult and costly. Discriminatory tariffs against dumping could do a great deal here, as they have done something in Canada, where the scope was smaller. And they would encourage the extension of our industries and make them stronger to combat competition both at home and abroad. Every progressive country except Britain already to some extent protects its market and industries from dumping. We have been the only nation to feel the full effects of this policy. With protection against this kind of thing, with preferential trading with our Colonies and Allies, and with organisation among our producers and traders, the enemy would have little or no scope for his tactics, and we could easily beat him. We could go on increasing our capacity and our businesses, our employment and commerce.

THE MODERN LANGUAGES REPORT.

THE Modern Languages Report recently issued covers a very extensive field. Among its recommendations is one to the effect that the systematic and scientific study of foreign countries be encouraged by the Foreign Office. A higher language qualification, the report states, should be required in the general Consular Service and for student interpreters for the Far East. Before going out, student interpreters should receive an intensive training at home in the language and phonetics of the country to which they are allotted. The report further asks that more opportunity be given to the officers of the Army and Navy to acquire knowledge of modern foreign languages. It is asked that phonetics form part of the training of all entrants to the public service whose duty will lie in foreign countries.

The business community in every considerable centre of foreign trade are recommended to combine with the education authorities to form institutes of languages; business men should encourage the study of foreign languages by apt members of their staff. Neither Latin nor Greek should be made compulsory for an arts degree in any of our universities. The new professorships and lectureships should be, some of language and philology, some of literature, some of the history of institutions, some of the economics of the five principal European countries. The number suggested is 55 professorships and 110 lectureships; the allowance for French would be half as much again as for each of the other four languages.

The report proceeds to deal with the study of foreign languages in secondary schools, and recommends that an institution be established in London, similar to the School of Oriental Studies, for the intensive study of the greatest possible number of European tongues, with the geography, resources, industries, and all valuable information concerning the minor countries. Emphasis is laid upon phonetic instruction, and upon the requirement of the aid of foreign assistants. Another recommendation deals with the study of the products, industry, trade, economic conditions of the chief European countries, and also of North and South America, Asia and Africa.

As will be seen from the above very brief abstract the report covers, as we stated, a very wide field, a far greater one than would be expected from its mere title. The language question is perhaps rather out of the scope of the subjects we usually deal with, but we view the recommendation with respect to our consular service with very great pleasure, in that it shows a tendency on the part of the Government offices to appoint for British consular duties British citizens only; hitherto the number of non-British subjects, and subjects who have proved to be enemy subjects, who were officially appointed to take charge of British interests abroad, was nothing less than calamitous.

Stress is laid in the recommendations upon phonetics, and upon phonetics acquired in this country. A number of professors and lecturers are recommended for appointment in each centre in which instruction in foreign languages is to be given. If we take the French language, for example, we suppose that care will be taken to appoint in the same centres professors and lecturers taken from different parts of France, with a view thoroughly to acquaint British students not only with perfect French, but with the accent habitual to the North of France, to Paris, to the Centre and to the South of France. We may give the following illustrations to make our point clear. A British student who has not had the advantage of listening in this country to a lecturer from the South of France will not have had the opportunity to acquaint himself with the accent current in that part of the country, nor with the extraordinary use made there of the past-definite. He will have learned *nous sommes allés*; *nous avons été*, and will be utterly lost when he hears, instead, *nous allâmes*; *nous fûmes*. The use of the past-definite tense in French, one of the peculiarities of the South of France method of speech, is correct; it is even painfully correct. It is a critical tense to use in writing; it acts like a maelstrom, for when once a piece of writing is started in that tense there is no leaving it, and the past-definite ending of most French verbs sounds ridiculous to other than Southern French ears. We may add the following as other, but *vice versa*, examples of the effect of accent or phonetics. A French citizen who has learned English in France from a Scotch, or from a Welsh, teacher exclusively, has no difficulty in differentiating from each other the two words *work* and *walk*, among very many other instances of words having a very similar pronunciation. If, however, he come to London, he is entirely lost, as far as these two words are concerned, for the simple reason that the Scotch accentuate each letter. Not that the Scotch pronunciation has not its pitfalls for a foreigner; we defy any foreigner, even Scotch taught, to find out the orthography of the proper noun *Searl* in the Scotch pronunciation *Sarrol*. Therefore the recommendation "that before going out student-interpreters receive an intensive training at home in the language and phonetics of the country" is, to our mind, a difficult proposition. It is not insurmountable, as we could instance, but it requires a series of good teachers. The study of languages demands, above all, on the part of the student an inclination, a bent for the particular language or languages. It has always been, and will always be, useless to attempt to teach languages indiscriminately; a selection will have to be made among the students following the whole curriculum of a class, a selection which in the first place must start from the consciousness of the student himself, although much depends in the study of languages, as in all other studies, upon the qualifications of the teacher and the amount of interest with which he can surround his work.

It is quite true that one knows a language only when one has acquired the grammar of that language, but it is quite wrong, as many authorities have stated over and over again, to commence teaching a language by loading the brain of the student with numerous rules and innumerable exceptions. Words should be taught first, then the use of these words, and we have found no better method of learning a language among the many methods in existence than the one frequently ridiculed as containing only impossible phrases. These phrases remain imprinted on the memory and have their full effect.

The report also recommends that a committee be appointed to inquire into the potentialities of artificial languages and the desirability of encouraging the development and use of one. We need not enlarge upon this. Before a universal language can be established much unification work must be done, such as the establishing of one single temperature scale, one single series of weights and measures, and so forth. French engineers having dealings with Great Britain, and knowing enough of the English language for ordinary purposes, are quite at a loss when they are given temperatures in Fahrenheit degrees, and proportions of furnace charges in hundredweights. If we could talk to our foreign friends in their own language and freely use their own measurements, business facilities would be greatly increased. This is the object of the vast programme of the "Modern Languages Report," and we wish the promoters every success in their endeavours.

ELECTRIC POWER FOR OIL-FIELD REQUIREMENTS.

IN the early days of electric power transmission the visitor to a primitive oil field would scarcely have recommended the introduction of electric apparatus, apt to spark, into localities in which suspiciously-smelling gases spread from the mouth of the oil wells, and where he was cautioned not to strike matches. As a matter of fact, it is only within quite recent years that electric power has gained a firm footing in oil districts, and this not only for considerations of safety. Though there was an oil industry before an electric industry in the modern sense had grown up, the brisk development of both these industries dates back to about the same period of the past century and to days in which the electric motor possessed little of the adaptability and reliability which have made it so valuable since. Thus the steam engine, later rivalled by the internal combustion engine, commanded the field, there was hardly any literature on electric power for oil drilling before 1913, and even at present Mr. J. Wilfred Burford, M.Inst.M.E., A.M.I.E.E., in presenting a paper on "The Application of Electric Power to Oil Field Requirements,"* to the Institution of Petroleum Technologists last Tuesday, estimated that 60 per cent. of the oil districts power was provided by steam plants, 35 per cent. by gas and oil-engines, and 5 per cent. by electric motors. Progress has been rapid of late, however. When Mr. Rappoport spoke on the "Internal Combustion Engine on the Oil Field" before the same institution three years ago, he gave the following figures for the years 1910–11–12–13, and the Baku oil district: total numbers of wells 3,001, 2,964, 3,422, 3,760; wells operated electrically, 361, 440, 657, 1,002. Electric power has made great strides in the last years mentioned, therefore, and from information which Mr. Burford had received since drafting his paper, the capacity of the electric generating plant at Baku had grown to 70,000 kw.; Rumania had about 200 wells operated electrically aggregating 14,000 h.p.; electric motors were used last year in the Singu field of Upper Burmah, and in America 1,750 wells aggregating 38,000 h.p. were driven electrically; 23,100 h.p. out of the latter total were used in California, the oilfields of the Appalachian Range and of Kansas City being next in importance with more than 5,000 h.p. each; one well in Western

* The paper was read in the author's absence; Mr. Burford was for some time in the Peru oil district, to which he referred in his paper.

Virginia had been electrically driven to a depth of 3,100 ft.

That electric power has had a hard struggle to secure a footing in oil fields is not to be wondered at. If a productive oil source were to be struck to-morrow in England, electric power would at least be as ready at hand as steam power. But when oil is spotted in some out-of-the-way place, and extensive drilling has to decide in the first instance whether the occurrence is likely to justify the laying down of plant, the prospector will take the power which he can obtain within reasonable time and cost and which he can manage, and he will try to get on with boilers and steam or oil engines without bothering about first converting his primary energy into electric energy for more economical working. Oil fuel or gas fuel may be available after the first success, and the relative efficiency of his plant will be a secondary question. When afterwards oil flows plentifully, the company is apt to act on the principle that big production beats small economies, as long as the good time lasts. It might be shown to them that the steam plant efficiency will hardly rise above 4 per cent. in oil drilling, while gas and Diesel engines may realise 30 and even 50 per cent., by utilising waste heat, and that electric motors promise even higher economy; Mr. Burford was rather optimistic in these latter estimates and hopes. The engineer on the spot will hesitate to risk, with his unskilled men, breakdown of the electric transmission and machinery which may mean a long shut down. Every industry has to learn its own lessons, moreover, and the husbanding of natural resources is quite a modern doctrine. Twenty years ago, Mr. Burford pointed out, it was usual for a colliery to consume 10 or 12 per cent. of its output for its own working, a figure which electric supply from centralised plants had reduced to 3 per cent. The Baku oil fields used in 1913 15 per cent. of their oil for fuel, representing a value of 2,600,000*l.*; in another field the fuel demand per month amounted to 250 tons out of a total of 6,000 tons.

Power is needed on the oilfield for a great many different purposes, and almost everywhere heavy load fluctuations have to be reckoned with. There is the drilling of the well by different systems which put very different demands on the machinery; the raising or production of the oil by pumping and by other means; the repair of the wells, pulling up rods and tubing, cleaning out cavings, &c., and finally, the general power requirements for the storage and transport of the oil, for water, lighting, the shops, &c. The problems are similar and far more complex than in electric loom driving, crane working and in rolling mills, where their solution took a much longer time than the general advocates of electric power had anticipated. Because of these difficulties Mr. Burford discussed the tasks the different machines have to perform, before speaking of the type of motor and system to be adopted.

As regards drilling, three chief methods are in use. In cable tool drilling the power is imparted to a band wheel, about 12 ft. diameter, which through a crank and wrist pin on one end of its shaft raises and drops the tool; on the opposite end of the shaft is a chain-sprocket wheel clutched with the calf-wheel which works the casing of the well. The bull wheels, on the shaft of which the drilling line is spooled, are connected by ropes with the band wheel, beyond which is the sand reel (worked from a 40 in. friction pulley), on which is spooled the steel sand-line for baling detritus from the well. A wide range of speed and fine regulation is essential for these various operations, especially when drilling with a manila cable, as the motion of the walking beam, from which the drilling tools are suspended, must synchronise with the natural period of vibration of the drilling line; these difficulties are not so pronounced with a wire line. The number of blows, 60 at the top of the well, will decrease to 25 at a depth of 1,200 or 1,600 ft., if a manila line should be retained to that depth; generally, however, the manila line is discarded at 500 ft. depth and replaced by a wire line, which allows of greater speed at greater depth. The band wheel speed requires fine regulation especially for the range between 30 and 50 revolutions, but a top speed of 65 revolutions and a slow creeping speed are also wanted. Raising the tool will call for from 15 to 25 h.p., the stroke varying from 2½ to 5 ft.; to draw the tool from an 8 in. hole at an average speed of 250 ft. per minute will need 30 or 35 h.p. for about 10 minutes in a hole of 2,500 ft. deep. The next operation, baling the detritus from the well, will demand 25 h.p. or 30 h.p. for three or four runs, each of about 5 minutes. The casing operations make the heaviest and most fluctuating power demands (more than 100 h.p.) The power may fluctuate with frequent reversals, and a high torque must be available at slow speed. Here, Mr. Burford thought, the superiority of the electric motor over the oil or gas engine for drilling operations was particularly striking. On the other hand the readiness of the electric motor to take up overloads might, in absence of proper supervision, lead to the derrick being pulled in or the pipe in the well being parted during pulling operations.

The second system of drilling, the pole tool system, makes use of iron rods of about 1 in. diameter, 40 ft. in length, for raising and lowering the drilling tools; the walking beam is much shorter and heavier, and the motion more rapid than in the first method, at the top of the hole, 80 strokes of 12 in. or 24 in. being given per minute. The power, transmitted from the engine to a 6½ ft. band wheel, is very slightly in excess of that needed for the cable system. In pulling the tool from the pole, each section of drill pole has to be disconnected and set up in the derrick. For this purpose the driller "races" the engine by means of a "lightning" valve worked by a foot paddle, and then pulls over the belt tightener causing the tools to be drawn up the 40 ft. at high speed, within 10 seconds, with 15-second spells of no load between the pulls; about 30 h.p. will suffice for this work. The third method, the rotary system, does not call for very exact speed regulation, and would appear to present the most suitable conditions for electric motor drive. During the rotation of the drill and in working the mud-pumps the load will remain steady for considerable periods, and the economies to be realised in fuel and labour are pronounced. As the mud-pumps take much steam, two steam boilers each of 40 h.p. are usually put down, consuming 2 or 3 tons of oil fuel per day and requiring the attendance of two men. The electric rotary drill is a novelty, however. The first three shallow wells drilled on this system date only from 1914 and 1915, and the maximum depth so far reached on this system is 1,500 ft.

Passing to the production of petroleum, by pumping, in the first instance, Mr. Burford pointed out that it was the common practice to pump with the aid of independent power, leaving the drilling and machinery in place, or else to instal a 30 h.p. gas engine with reversing clutch and a light form of rig and derrick. The whole duty could be performed by single speed or two-speed electric motors at much reduced costs, the low speed and power serving for pumping and the high speed for pulling rods and tubing and for cleaning out. "Group-pumping" was resorted to for moderate and fairly permanent production, from 6 to 18 wells being connected by "jerker lines" to a central pumping power, driven by a gas engine of 20 or 30 h.p., which might be replaced by a 15 brake horse-power motor (owing to the different ratings used by manufacturers). In the permanent production by baling, the second method of production, very large balers, sometimes 12 in. diameter, 60 ft. long, were used at Baku, and they raised a great deal of sand and water together with the oil; baling at the high speed of 1,000 ft. per minute required up to 150 h.p., and as the steam at 60 lb. per sq. in. had to be supplied through long pipe lines, the method was obviously very wasteful. Recently internal combustion engines had been installed for baling groups of fairly close wells, but electric motors would certainly prove more economical and adaptable still. The third method of production, by swabbing, is used chiefly in the Galician oil fields at Boryslaw-Tustanowice. The swabs are operated by direct-acting double-cylinder winding engines, locally known as haspel, and listed in size from 50 h.p. up to 200 h.p.; the swabs are raised at speeds of 2,000 ft. per minute and the load being very intermittent, the overall efficiency of these engines is very low. Though Mr. Burford was not able to give any actual power figures, he could show that electric motors, probably of the same primary cost as the engines working with steam at 140 lb. per sq. in., would operate much more economically than the haspel.

Electric motors can undoubtedly perform all the difficult operations which drilling, baling, &c., at badly fluctuating loads involve. With the aid of rheostats and other devices the necessary speed regulations can also be secured; but that would be wasteful, and whether or not such apparatus can be entrusted to the driller on the derrick, is a question, about which some of the speakers at the meeting differed from Mr. Burford's optimistic views. His detailed cost estimates, very much in favour of electric power plants, were also criticised. As regards system he advocated polyphase working, which is indeed most in use, as he showed by references to installations chiefly of the General Electric Company. With respect to motors, he would, with others, keep drilling and pumping apart and use in both cases two types of motors, a single-speed and a two-speed machine. His single-speed motor is equipped with a change-over switch mounted on the frame to connect the stator winding either in star or in delta, the star for pumping, the delta for pulling rods and tubing. The two-speed machine is, by a switch, connected for 600 r.p.m. or for 1,200 r.p.m. He would prefer this variable-speed motor for drilling; but as the many operations in drilling follow one another rapidly, and the driller must not be bothered too much with throwing-over pole-changing switches, Mr. Burford would put up with the standard type of motor at some sacrifice in efficiency. Mr. R. J. Ward, who had recently returned from Baku, mentioned that polyphase motors answered very well up to 300 kw.-hours per day; for heavier work oil engines were certainly cheaper, and for baling the electric motor was not to be recommended, as it started baling at the full speed of 1,000 ft. per second, creating a big suction, and was apt to overrun at the top and when clutched to burn out; that was a serious trouble, yet they certainly liked the electric motor, though not for all work. Mr. Templeton pointed out that the brisk development in electric power, to which Mr. Burford had referred in connection with Mr. Rappoport's table, had taken place together with a general development in the oil industry, and in internal-combustion engines and in oil prices. The question at present is, as Mr. Cunningham Craig put it, one of education, to train either the driller to the use of electric apparatus, or the electric engineer to the study of the requirements of the oil engineer. The latter was also one of the main objects for which Mr. Burford had compiled his instructive paper.

RIVETING RECORDS IN SHIPBUILDING.

SHIPS and yet more ships is the insistent call of the hour since the acceleration of shipbuilding has become a war necessity of the first importance. In dealing with the various aspects of the question of ship production considerable attention has been directed to that section of shipyard labour known as the "black squad." For some years past there has been a serious shortage in the supply of labour of this description, and, under war conditions, this deficit is intensified. Again, although often the weather conditions are adverse, the work physically arduous, and overtime excessively called for, the time-keeping of these men in our shipyards has been the subject of much comment and question.

These few remarks indicate broadly the necessity of taking advantage of all factors which can conceivably have a stimulating influence on overall production, especially where the stress of adverse circumstances is keenest, and to this end the Admiralty decided to publish figures of the tonnage of shipping sunk and completed in such a manner as to foster the spirit of competition and the sporting instinct of the Britisher. It is but a logical development that already this spirit should have led to competitive tests in one section of the work—riveting—and especially is this satisfactory since there is perhaps a more serious shortage of man-power in this trade than in any other. Riveting lends itself to the carrying out of competitive tests, since in this case performances can be compared merely by the counting of the rivets driven per unit

of time, provided other factors to be enumerated later are sufficiently constant.

In keeping with the trend of progress and stimulated by the serious shortage of labour, machinery to replace hand work is being increasingly adopted for riveting, and the conception and routine of shipbuilding amended to facilitate an increase in the application of such machinery. To this end, for instance, efforts are made to arrange the delivery of raw material and the progress of work, so that as much riveting as possible can be done on the ground before erection in place on the ship, when probably either machine riveting could not be carried out, or could only be undertaken under such difficulties as would seriously lessen the rate of working. Such procedure is fabrication within the yard itself, and is not "fabrication" in the general sense implying the building of sections in works apart from the shipyards.

Name and Date.	Place.	Hand Press or Percussor.	Diameter of Rivet.	Quality of Work.	Location.	Record of Performance.	Rivets per Hour.	General.
R. Farrant May 7	London	Percussor	$\frac{7}{16}$ in. dia.	Margarine tank	On ground	4276 in 9 hours	475	Hammer held by hand, weight 28 lb.
D. Devincy May 14	Dalmuir	Pneumatic press	$\frac{7}{16}$ in. dia. by $\frac{7}{8}$ in. to $\frac{7}{16}$ in. long	Ship frames	On ground	4422 in 9 hours	491	Squad consisted of riveter and two holders up and two heaters; riveter put the rivets in place himself.
C. Knight May 16	Baltimore	—	$\frac{3}{4}$ in. by 2$\frac{1}{2}$ in. long	—	—	4875 in 9 hours	542	Negro riveter.
W. Moses May 23	Barrow	Percussor	$\frac{5}{8}$ in. by $\frac{3}{4}$ in. dia.	Gun work, 9.2" Howitzer	On ground	5894 in 9 hours	655	
H. Briggs	Brooklyn	—	$\frac{3}{4}$ in.	—	—	7864 in 7$\frac{1}{2}$ hours	1,049	Reported ship-repair work relays of helpers.
W. Smith	Clydebank	Percussor	$\frac{3}{4}$ in. long by $\frac{7}{8}$ in. and $\frac{3}{4}$ in. dia.	Ship girders	On ground	6783 in 9 hours	754	Boyer pneumatic hammer held by hand; two holders up, two rivet boys and one riveter in squad; weight of hammer, 20 lb.

The riveting machinery that is replacing hand work is operated almost universally by hydraulic or pneumatic power, and is of two types—the press, and the percussor. With the press type the work is either laid in position on skids or held in position by hand, and is fed between the jaws by hand. The riveter merely locates the work correctly in relation to the piston and actuates the lever operating the control valve. The percussor type, which is a hammer rapidly actuated by compressed air, is carried normally by the riveter, although in awkward places it can well be slung, as for instance, when riveting the bottom plates of a ship. The usual squad for such riveting consists of one riveter, one holder-up and one heater (boy), whilst for hand riveting, two riveters are required per squad to give sufficient blows whilst the rivet is hot. For certain jobs such as press riveting, extra hands are often required for feeding the work into the machine.

The record figures which have been published represent both types of power riveting with various sizes of rivets, under unequal conditions, and generally with an increase above the normal in the number of helpers feeding the riveter. In order to attempt a comparison of these records, the various factors influencing performance require to be kept in mind.

1. *Hand, Press or Percussor Work.*—Hand work is the slowest and press work is, in general, the fastest. This factor is of maximum importance.

2. *The Diameter of the Rivet.*—Assuming that the necessary temperature has been reached, then the larger the diameter the longer the time required to stave up, this factor being more important with hand and percussor riveting than with the press work.

3. *Length of Rivet.*—This factor, *per se*, can have very little, if any, influence on the staving time. The longer the rivet the more difficult to place the heated rivet in position for hammering up—but once in place the actual time of hammering up does not vary with length of rivet.

4. *The Quality of Work.*—Boiler and oil tank work, or where water or oil tightness is required, will naturally take longer than ordinary internal work, as the rivets require more hammering to completely fill the holes or the countersinks in order to ensure the required degree of tightness.

5. *Spacing of the Rivets.*—The wider the spacing, the less the number of rivets that can be driven in a given time, particularly in connection with press work, where the job has to be hand fed into the machine.

6. *Type of Rivet.*—The countersunk rivet with pan head takes longer if hand or percussion riveting is being carried out, whilst with press riveting it is almost immaterial whether countersunk or boiler points are in question.

7. *Location.*—This factor is of prime importance, as riveting on a staging is normally much slower than on the ground, and in places where the staging cannot be suitably arranged the difficulty is intensified.

8. *Material.*—Iron rivets can more expeditiously be dealt with than mild steel—the usual material—while high tensile steel rivets are more difficult to work than mild steel.

9. *Preparation of the Work and Thickness of Plates.*—The thickness of the plates has little influence (see length of rivet), but if the screwing up before riveting is not well carried out the efficiency of the finished product will suffer more than the speed of accomplishment. If the holes are not fair, time will be lost in setting the rivet and in remedying faulty work.

10. *General.*—Awkward corners and general conditions all have an influence. With outside work, the weather, if bad, will hinder output.

The number of helpers and rivet boys in the squad may vary, and, in making comparisons, all the foregoing factors play a more or less important part, as will be seen from the annexed table. It will be seen that the amount of work involved per rivet varies considerably. It is impossible, accurately, to work out factors which would allow for all the conditions in question; nor generally does this detract in any way from the splendid work involved in carrying out these feats and the advantages of the spirit of emulation underlying these performances.

It is to be regretted that the Boilermakers' Society are prohibiting any more record-breaking attempts in the fear probably that the data so obtained will be used to cut the riveting piece rates with the inevitable consequences. When it becomes known in a yard that an attempt is being made to break a record the adverse effect on the work of all departments in the yard is considerable. To quote from a daily paper as an example: "He finished his task amid enthusiastic cheers from thousands of his fellow-workers." This latter, however, is quite a hopeful point, as enthusiasm in work cannot become too general.

The utility of these records is that they go to show what can be done when the spirit of competition is introduced, and we look to our shipyard managers to introduced systems of remuneration that will foster this sporting proclivity and extend them to wider spheres of work, the advantages of which these records are the proof.

INTERNAL BALLISTICS.

PAPERS on ballistics hardly lend themselves to abstracting, and publication of researches on technical ballistics are not desired at present. Lieutenant-Colonel A. G. Hadcock, R.A., F.R.S., discoursing on "Internal Ballistics" at the Royal Institution last Friday, gave, however, so clear an account of the fundamental problems, from the engineer's point of view, and of recent advance made in their elucidation, that a brief notice of his lecture will be welcome.

The science of ballistics, Colonel Hadcock stated, divided itself into two branches; the one branch, external ballistics, dealt with the motion of the projectile after it had left the gun, while the other, internal ballistics, investigated the motion of the projectile while in the gun. The gun, it had long been recognised, was a single-stroke engine, and a very inefficient one at that. The first indicator diagram of a gun was, the lecturer said, to be found in the "New Principle of Gunnery" which Benjamin Robins—who belonged to a Quaker family—published in 1742. Robins assumed that the temperature of the inflamed powder was that of red-hot iron, that the pressure rose to 6·6 tons per square inch (1,000 atmospheres) just before the shot moved, that all the powder was burnt and that the pressure curve was an ordinary hyperbola, corresponding to isothermal expansion—all incorrect assumptions which were yet considered sufficiently exact during a century. This indicator diagram preceded that of James Watt (1784) by forty-two years, and looking at Robins' diagram one might almost believe that Watt owed to this diagram his idea of obtaining efficiency by allowing steam to expand. But the gun, the lecturer continued, was essentially an internal-combustion engine (not a steam engine), the propellant or charge of which contained all the oxygen necessary for its combustion, and the only indicator generally available, the crusher gauge, merely gave the maximum pressure. The charge began to burn at atmospheric pressure; the rising pressure first forced the copper driving band of the shell into the rifling grooves, then forced the shell along the gun and, the charge having completely been burnt, the expanding gas finally drove the shell out of the gun. The "engraving" of the driving bands was one of the most important of these processes; the greater the resistance to the engraving, the larger would be the proportion of the charge burnt before the band was fully engraved. In calculating the energy of the charge, it was customary to replace the actual volume occupied by the gas by the unit of gravimetric volume, a term introduced by Andrew Noble and Abel in 1875. Their law, which was based on experiments with black powder, was still generally accepted by artillerists here and abroad; the law was $p = R \cdot \Delta/(1 - \alpha\Delta)$, where p was the pressure in tons per square inch, R. an experimental constant and Δ the gravimetric density, *i.e.*, the density (referred to water) of the charge supposed to be spread uniformly throughout the volume of the vessel. As 1 lb. of water at 62 deg. F. occupied 27·72 cub. in., $\Delta = 27{\cdot}72\ W/C$, if W indicated the weight of the charge in pounds and C the capacity of the vessel in cubic inches. Introducing the unit of gravimetric volume $v = 1/\Delta = C/27{\cdot}72\ W$, the formula assumed the simpler form $p = R/(v - \alpha)$. The α was, in the case of the black powder, to represent the residual solid portion of the charge always remaining in the vessel after explosion (estimated at 57 per cent. of the powder volume). Colloidal smokeless powders (cordite, &c.) left no solid residue, but the α term was found to persist; it was called the co-volume, and might be described as the space occupied by the unit volume of gas at infinite pressure, corresponding to the volume occupied by the gas molecules themselves in the equations of state of Clausius and of Van der Waals.

In the gun chamber the unit volume varied as the charge was being burnt. If v^1 represented the v due to the burning of the fraction z of the charge, then $v^1 - \alpha = (v - \alpha)/z$, where v was the gravimetric volume after the whole charge had been converted into gas. There was also compression of the powder gas. Sir Andrew Noble had first studied the phenomena in closed cylindrical vessels, in which the pressure sometimes rose to 20 tons per square inch, and which suffered a longitudinal expansion of 0·5 in. Combining the crusher gauge within the vessel with a revolving drum outside, on which a tuning fork was drawing a time curve, Noble had determined the time curve of the rise of pressure from which he could deduce the fraction of the charge already burnt. This burning (Vieille and

Noble) always took place in layers parallel to the surface of the powder grains, that is to say, a cylinder of cordite burning in the gun remained a cylinder and a tubular charge remained a tube, burning both outside and inside. The amount of powder burnt per unit time (0·001 second) was proportional to the instantaneous pressure, though artillerists differed somewhat as to the exact ratio. We had further to consider that the shell was moving along the gun, and artillerists had so far treated the problem either as if the gun were a closed vessel for each position of the shell (Centerval and Mansel), or as if the pressure for each position of the projectile bore some definite relation to the pressure which would have been developed, had the charge been burnt in a closed vessel of the capacity of the gas chamber (Gossot, Heffernan, Charbonnier). Neither of these assumptions was correct, because the motion given to the projectile was not linear, and much energy was absorbed by the shell.

It had further to be borne in mind, the lecturer continued, that the space behind the projectile was continually increasing, and that the gases hence lost heat, but also gained heat by the continued combustion. He had found a key to the solution of the pressure problems in Clark Maxwell's diagram of isothermals, a series of curves plotting the p v for different temperatures t_1, t_2, &c. If these curves were supposed to relate to the definite fractions 0·1, 0·2, &c., of the charge already burnt, the resulting "isopyric" lines enabled them to find the v, *i.e.*, the momentary position of the shell in the gun, from the observed pressure. If the combustion were to stop with the burning of the fraction z, the curve would be adiabatic, but as the combustion continued, the curve would be intermediate between adiabatic and isothermal expansion, and the function was $p\left(\frac{v-a}{z}\right)^{\epsilon}=k$. For adiabatic expansion ϵ was 1·41, for isothermal $\epsilon=1$; for internal combustion engines the value of ϵ was about 1·23, and the mean value of ϵ for guns seemed to be 1·1. The constant k depended upon the resistance offered by the driving band to its engraving and to its subsequent motion. The lecturer here interposed the remark that this resistance was needed; for if there was no resistance, only a small charge could be burnt and the muzzle velocity of the shot would be restricted. The driving band resistance varied inversely as the calibre of the gun, and depended upon the width and form of the band.

The actual static pressure required to force the band into the rifling reached its maximum, as shown by diagrams, when about two-thirds of the width of the band had been forced into the rifling. While this engraving went on, the gas pressure, always much higher than the necessary hydraulic pressure, rose steadily, and the shot might acquire a considerable velocity during this short period. For the moment of full engraving the formula was $\left(\frac{v_0-a}{z_0}\right)=k^1$, and other final formulæ were dededuced for the short period during which the fully engraved projectile was moving and for the conditions after the complete combustion of the charge. Thus, the lecturer concluded, with the aid of these formulæ and the isopyric curves, expressions could be deduced for the velocity of the shot at any position in the gun and also for the muzzle velocity, as well as for the maximum pressure. When the pressure reached its maximum, nearly 0·7 of the charge had been burnt, and the velocity of the projectile was about 1,100 ft. per second in a 6-in. gun. During the combustion of the remaining 0·3 of the charge, the pressure fell to half its maximum value, but the velocity increased to 2,600 ft. per second, and the energy to seven times the previous value, owing to the expansion of the gases. At the muzzle the pressure was reduced to 4·5 tons per square inch, and the muzzle velocity was 2,910 ft.

COAL CONSERVATION SUB-COMMITTEE.—We have received from the Engineers' Club, Albert-square, Manchester, a pamphlet entitled "Electric Power Supply of Great Britain," and containing a report of a debate which was held at the club on March 5 last, on the interim report of the Coal Conservation Sub-Committee. Copies may be had on application to the Hon. Secretary, the Engineers' Club; price 4*d.* each, including postage.

NOTES.

ELECTRICITY RECOVERY FROM ELECTRIC TRACTION LINES.

As soon as electric propulsion of vehicles was introduced, the fact was recognised that an electric motor, when not actuated by the supply current and not turning the car axle, but when itself turned by the axle on going down hill, is converted into a generator which sends current back into the system and exerts a braking instead of a propelling effect. When electrical engineers had convinced themselves of the reality of the effect, which had been foreseen, of course, the possibility of recovering or regenerating electric energy on mountain railways became one of the arguments in favour of electric power *versus* steam power on such lines. It was soon found, however, that the apparatus necessary for the recovery and safe operation complicated the machinery on the locomotive and in the power house. The experience gained on the first line on which recovery was attempted—the Giovi railway leading from the Apennines down to Genoa—was hardly encouraging, and when less than ten years ago it was decided to adopt electric propulsion on the Gotthard Railway, experts were against electricity regeneration. The decision might have been different, if the regeneration had not, at that time, appeared restricted to three-phase working which was considered unsuitable as it necessitated a double line of conductors. Meanwhile, noteworthy progress has been made in this domain, chiefly in the United States; different current systems of traction have been adapted to regeneration, and the modification of the electric service on the Gotthard line, we see from an article by Professor W. Kummer, in the *Schweizerische Bauzeitung* of May 1, comprises experiments on this point. Considering mainly traffic conditions, Kummer concludes that, with a fairly frequent train service, the recovery should prove economical, especially where coal is expensive, and even in cases where the primary power is hydro-electric. The electric problems at issue were very ably discussed last year before the American Institute of Electrical Engineers by Mr. R. E. Hellmund, of the Westinghouse Electric Company. Hellmund distinguishes resistance braking, when the current generated by the motor is absorbed by resistance on the vehicle, regenerative braking, when the current is returned to the supply system, and combinations of the two methods, and he explains how the problems can be solved and have been solved in various ways for different systems. With three-phase working hardly any additional apparatus are required, except that rotating converting devices (such as frequency changers) might be overspeeded on down gradients when supply is interrupted; over-speed relays, used for similar reasons with synchronous converters, help over that difficulty. The phase-converter system (single-phase line and induction motors) offers very similar, simple problems; this system is in use on the Norfolk and Western Railroad, and was in fact adopted there, because it promised current regeneration. The direct-current series motor cannot as such be used as a generator; but with the aid of separate excitation, constant or variable, successful solutions have been worked out on the Lake Erie and Northern Railroad (working pressure 1,500 volts—2,000 volts maximum during regeneration), and on the Chicago, Milwaukee and St. Paul Railroad, the biggest electric railway of the year 1915, at any rate, 440 miles long. The two motors of a locomotive are on that line coupled in series for 3,000 volts. The alternating-current commutator motor system avoids the flashing difficulty of direct-current motors, but introduces other difficulties, which can be solved in various ways, however, more satisfactorily than was done on the Midi Railway in France. Hellmund's conclusion was that regenerative braking would soon assume great commercial importance for heavy railway work and would win over some railways, now operated by steam, to electric propulsion.

FLOTATION OF ORES.

Within the last fifteen years the concentration of certain low-grade ores which used to be effected by gravity with the aid of tables, jigs, vanners, &c., has more and more been carried out by flotation processes, *i.e.*, processes depending upon surface tension and the preferential adhesion of liquids and gases to certain minerals which are raised from the agitated pulp and float on the surface as a film or as a froth, while the gangue and other minerals settle at the bottom. In spite of great progress, however, flotation remains practically restricted to sulphidic ores, though free gold and gold telluride and native silver and copper can also be floated. Oxidic ores are not yet floated as such on a commercial scale; they are, however, sulphidised, *i.e.*, treated with hydrogen sulphide or sodium sulphide to make them amenable to flotation. Yet even the treatment of sulphidic ores, and particularly of the slimes of these ores—the slime question is frequently all-essential—offers such complex problems that a body like the United States Bureau of Mines is continuously being asked to advise. In response to these inquiries, Mr. Oliver C. Ralston has, on behalf of the Bureau, drawn up "Answers to Questions on the Flotation of Ores" (Technical Paper 149). The fundamental theoretical questions still remain unanswered, but the paper contains many useful hints. There is very little film or skin flotation so far. It is almost all froth flotation, a froth being created by introducing air into the watery pulp to which a little oil is added. In mechanical flotation the air is beaten into the pulp, and the froth is less evanescent than in pneumatical flotation, in which the compressed air is forced into the pulp or some gas liberated in it. The mechanical method yields a better extraction of the coarser particles, the pneumatic method answers better for slimes and for total extraction and requires less power; either method may have advantages, or the one treatment should follow the other. The more dilute the pulp, the cleaner the concentrate; but the extraction falls off with dilution. A truly colloidal slime ("primary slime") is very difficult to deal with; at the Inspiration Consolidated Copper Mines iron filings or granular matter (sand) are added to the slimes to give a better froth. Oil is always used in America, though there are many flotation proposals for dispensing with oil; some oils (pine oil) are valued as frothers, others (coal-tar oil, petroleum products) as collectors. When raw oil is poured on the froth, it produces a hole in the froth and clears the surface, somewhat as in calming the waves of a rough sea; the oil must be stirred to make the froth reappear. Over-oiling is injurious to flotation. In recent litigation the United States Supreme Court sustained the basic patent of the Minerals Separation Company, which claims that, when less than 1 per cent. of oil, calculated on the weight of ore, is added to the pulp, a new effect is obtained, different from the use of more than 1 per cent. of oil. As a consequence, many works now use more than 1 per cent. of oil to avoid the payment of royalties; Ralston mentions that some works have observed no change when working with 3·3 per cent. (instead of less than 1 per cent.) of oil, and in the Court demonstration 25 per cent. of oil were used by the defendants, apparently without materially affecting the result. Acids are sometimes, salts of heavy metals mostly, deleterious to flotation. Complex sulphides of zinc, lead and iron, which are difficult to separate by flotation, may be roasted for an hour or two at low temperature, when only the iron pyrite is sufficiently oxidised to be picked out by magnetic separator. The water question is often important; waters from jungles, rich in tannin, and water containing much organic matter are unsuitable, and heavy rains washing clay into the water have spoiled flotation plants. Where water is scarce, the accumulation of acids and salts may necessitate a purification of the used water with lime and by other methods.

MECHANICAL STOKING.—Erith-Riley stokers, constructed in Lancashire, by Erith's Engineering Co., Ltd., 70, Gracechurch-street, London, have been ordered for the largest-unit boilers in Europe, viz., for double-ended Richardson-Westgarth boilers, 20,700 sq. ft. heating surface, hourly evaporation 100,000 lbs. from and at 212°, corresponding to about 6 tons slack coal hourly, at the Bow power plant of the Charing Cross Electric Supply Company, Limited. These units are remarkably compact, the total area including the stokers, being only 23 ft. by 36 ft., or 828 sq. ft. For convenience of working, a central wall divides the unit into two parts each with its 12-retort Erith-Riley stoker burning 3 tons coal hourly.

LITERATURE.

Aeronautics in Theory and Experiment. By W. L. COWLEY, A.R.C.Sc., D.I.C., and H. LEVY, M.A., B.Sc., F.R.S.E. London: Edward Arnold. 1918. [Price 16*s.* net.]

THE investigation of the aerodynamic basis of flight from both the theoretical and the experimental side has made such progress, that in the opinion of the authors the time has come, when the science of aeronautics should find a place in the curricula adopted by universities and engineering colleges. Though owing to the rapid accretion of facts the subject is not yet systematised, they submit a text book covering an appropriate course, and one that exhibits the solution of many problems that have been successfully attacked, while indicating others that await more thorough investigation. At the same time, recognising that the public are intelligently interested in the development of a new scheme of locomotion, and desire to be acquainted with the processes by which difficulties have been overcome and advance made possible, they have endeavoured to satisfy this curiosity by setting out the more salient steps in a form that can be followed and apprehended by those whose knowledge of mathematics is limited. It is to be feared that some slight disappointment may await this class. War conditions have prevented the authors revealing the whole of the results derived from experiment. The richest harvest has been garnered during the fierce heat of the war, and historically the work "illustrates the stage to which the science had developed just prior to the outbreak of hostilities." Evidently it would be injudicious to give descriptions of the latest designs with details of construction: not only do the diagrams not refer to machines of quite the most recent type, but some data may require to be modified when the present restrictions, imposing secrecy, have been removed. This prudence will commend itself to all, but it should be clearly understood that the authors are working under some restraint, and that in spite of such hindrances they have accomplished their aim of exhibiting a sound consecutive theory, limited primarily to the problems concerned in the interaction between the atmosphere and a heavier-than-air machine.

Whether the authors have been equally successful in making the conclusions intelligible to the non-mathematical reader may be doubted, though they have taken some pains in this direction. Those who are accustomed to follow a chain of reasoning by means of formulæ, hardly appreciate the difficulties that others find in interpreting this shorthand. Many will probably be able to follow the successive steps of a proof and test the algebraical accuracy of its deduction, but without grasping the reasoning or connection with the main argument, and this practice is attended with little edification; many more will be grateful to the authors for translating symbols into words.

The plan of the book is easy to follow. Limiting investigation to the aerodynamic basis of flight, that is excluding the internal-combustion engine and its connections, in order that the ends sought by aeroplane construction may be achieved, three distinct difficulties have to be surmounted. The machine must be supported, propelled, and possess reasonable stability during continued flight. To accomplish these three objects, it is necessary to investigate the behaviour of the fluid through which the machine travels; the form to be given to the several parts of the aeroplane in order to secure definite results with the smallest possible expenditure of energy, and the provision of means that will ensure steady motion during sustained flight in a disturbed medium. Each of these conditions is considered in turn and in the order named. The amount of information supplied varies according to the character of the investigations; in some directions it is limited only by the failure of mathematical analysis to cope with the difficulties presented; in others as much as prudence permits, but sufficient is supplied to enable the evolution of the aeroplane to be followed and to give a clear insight into the principles that have guided mechanical construction, and suggested the modifications that facilitate the fulfilment of particular purposes.

Of the actual atmosphere we know very little, and have applied dynamical and physical reasoning to hypotheses that find their chief support in continual repetition, but fail before the searching analysis of rigorous experiment and inquiry. If one correctly understand the allusions the authors have made to cyclones and anticyclones (page 33) to imply a revolving fluid mass about a vertical axis, we doubt the accuracy or relevancy of the explanation, and have an apt illustration of reliance on doubtful authority. But the motions of the atmosphere have to be considered from a physical rather than a meteorological point of view, and in this aspect limitations that are both necessary and warranted convert the actual atmosphere into a homogeneous fluid of a given density and viscosity. Compression—another property of the atmosphere—can fortunately be disregarded, for it is found that at the comparatively low speed of aeroplanes, compression effects are not manifested in the neighbourhood of the machine. Till aeroplanes fly with a velocity approaching that of sound, pressures brought into existence by flight motion are not sufficiently great to effect compression.

Whatever simplifications are introduced by the substitution of a perfect fluid for a viscous, and by the further limitation of the problem to one of two dimensions, the mathematical development presents much difficulty, involving as it does the theory of discontinuous motion. The treatment follows that indicated by Schwarz-Christoffel, and that which Mr. Levy has himself applied elsewhere. The result is to exhibit the degree of assistance analytical methods are likely to contribute in determining the conditions that prevail in aeronautical practice. Experimental control would be of immense service, but in dealing with an invisible gas any confirmation of results by practical experiment offers peculiar difficulties. The employment of water as a homogeneous, dense and viscous fluid, readily suggests itself as a suitable medium, and the substitution of hydrodynamic investigations has proved both useful and illuminating. The interpretation or the application of the results requires care. The authors have treated this problem as the somewhat analogous one of passing from a model to full-scale machines, as one of dynamic similarity. They are to be congratulated both on the success of their experiments and on being able to furnish so convincing a proof of the adequacy and applicability of their methods. Photographs of the flow and disturbance in air and in water under similar conditions of interruption of current by an obstacle show a striking resemblance. Many more of the minor details are seen than could have been anticipated.

The wind channel, designed to test the behaviour of models or parts of models when placed in an artificial air current, whose velocity can be regulated at will, has been so frequently described that it is not necessary to refer to its general construction or purpose. The description of the Chattock gauge in connection with a Pitot tube, furnishing results of surprising delicacy, emphasises the degree of accuracy to which it is necessary to carry experiment in order that the results derived from small models shall supply with sufficient exactness the data required for the construction of full-scale machines. Of more interest is the generic equation, due in its original form to Lord Rayleigh, which enables one to pass with confidence from small to full-scale work. It is shown that the resistance,

$$R = \rho v^2 l^2 f\left(\frac{vl}{\nu}\right),$$

where ρ, v and ν are, respectively, the density, velocity and viscosity of the air current, l is a linear quantity defining the size of the body, and f expresses the form of an undetermined function. It follows from this equation that when the experiment is so arranged that the value vl derived from the model is the same as for the full scale, that the resistances in the two cases are equal. This deduction depending on dynamic similarity is simple enough in theory, but difficult to realise in experiment. Usually the models of parts of aeroplanes are made one twenty-fifth of the full scale, and consequently to preserve the relation, the velocity would have to be multiplied by 25, giving rise to a speed that may easily amount to 2,000 miles per hour, and consequently one that could not be produced or measured accurately. What is normally done is to carry through the experiments up to such values of vl/ν, "as show the value $R/\rho v^2 l^2$ to become sensibly constant, and then to extrapolate by extending this curve to higher values of vl."

In subsequent chapters detailing the theory of aerofoils and the selection of most appropriate forms for other essential parts, the operation of the method can be followed, and sufficient is said to enable us to trace the effect of some particular design in modifying the aerodynamical function of the whole. If it be required to produce a machine that shall possess some particular qualification as increased swiftness, or greater ability to climb, or enlarged weight-carrying capacity, experiment will decide the most suitable form to be given to the several structural parts. Many variables contribute to the final result. These will be readily appreciated without enumerating them, but the effect that each contributes to the final result is considered here. Mechanical experience is no doubt the great factor in deciding the model forms likely to produce a desired result, but theory and experiment alike show the danger of trusting implicitly to intuition. Some characteristics may be little changed with variation of vl and experience is a sufficient guide. But experiments in water have shown that not only for every body does there exist a critical value at which the nature of the motion undergoes a rapid alteration, but that a change of attitude to the stream is practically equivalent to a continual change of shape, so that finally an approach to a critical velocity becomes possible. Similarly, in testing with models, the vl may be so related to the shape that a point of transition is reached, and a comparatively uniform eddying motion is suddenly replaced by one of violent turbulence. Such forms in which possible variations in velocity produce abrupt changes should clearly be avoided.

The parts hitherto considered generally concern the weight or drag of the aeroplane, whether necessary to ensure strength and stability to the design or to give the pilot the means of control and direction. Evidently of equal importance is the study of the forms of propeller, arranged to produce the horizontal motion that balances the drag. The engine that moves the propeller has no aerodynamical significance, but the nature of the thrust by which the forward momentum is communicated to the machine, the interaction of air and propeller, and the function which each part of the blade fulfils, are all of vital importance in deciding the design of an efficient air screw. As a mathematical exercise the discussion of the operating forces possesses great interest and apparently very considerable progress is made. The practical outcome is, therefore, the more disappointing, and almost with dismay one reads, "On account of the large number of factors, ultimately every new propeller is simply an intelligent modification of a previous one of known performance." Probably this statement is not to be accepted too literally. The scope of experiment is by no means exhausted, and we are reminded that the study of aeronautics is not sufficiently old to have given time yet for an extended research. This remark is applied to the Report of the Advisory Committee for Aeronautics, 1911–12, and one cannot doubt but that in the six years that have elapsed, many tests have been made and much learnt that it is not expedient to utter. In spite of this depressing outlook, we cherish the hope that it is possible with some approach to definiteness, to select a form that is best adapted for particular requirements.

The third section of the book, as intimated, attacks the theory of stability from the theoretical and experimental standpoint. In the general problem, the aeroplane is supposed to undergo a displacement of small amount and the question for investigation is, whether the resulting motion will tend to approach, or to diverge from that previously existing. The mathematics are not simple and the look of the determinants is sufficiently forbidding. But the authors believe that they have smoothed the path of the student by explaining the method pursued. The device of moving axes has been employed and it is claimed

that the equations have been derived as simply as possible. Only those who have tried other tactics are in a position to question this statement, and it is certainly easier to follow the authors' footsteps than to make a path for oneself.

We have endeavoured to convey the impression that we regard this work as one of great importance. It exhibits the present position of aerodynamic analysis and illustrates the competence and limitations of experiment in promoting improvement. The authors will not allow themselves to go beyond the point of confirming or emphasising the results published by the Advisory Committee for Aeronautics, but the work suggests a reserve of strength and implies an accumulation of facts and details that will facilitate construction in the future, and make the science of aviation advance with rapid and assured steps. Incidentally it is seen that the National Physical Laboratory has proved itself of enormous advantage to the Empire, not only by assisting in the direction here indicated, but by consistently upholding the importance of adhering to scientific principles, by maintaining a high standard of accuracy, and by devising tests that will safeguard the position attained.

BOOKS RECEIVED.

The Aviation Pocket Book for 1918. By R. BORLASE MATTHEWS. Sixth Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 6*s.* net.]

Canada Department of Mines. Iron Ore Occurrences in Canada. Compiled by E. LINDEMAN, M.E., and L. L. BOLTON, M.A., B.A.Sc. With an introduction by A. H. A. ROBINSON, B.A.Sc. Two Volumes. Vol. I. *Descriptions of Principal Iron Ore Mines.* Vol. II. *Descriptions of Iron Ore Occurrences.* Ottawa: Government Printing Bureau.

New Towns after the War: An Argument for Garden Cities. By "NEW TOWNSMEN." London: J. M. Dent and Son, Limited. [Price 1*s.* net.]

How an Aeroplane is Built. By STEPHEN BLAKENEY. London: *Aeroplane* and General Publishing Company, Limited.

Welfare and Housing. A Practical Record of War-time Management. By J. E. HUTTON. London: Longmans, Green and Co. [Price 5*s.* net.]

Proceedings of the Royal Institution of Great Britain. Vol. XXI, Part III. London: Published by the Institution.

Mechanical World Year Book, 1918. Manchester and London: Emmett and Co., Limited. [Price 1*s.* net.]

Transactions of the Institution of Civil Engineers of Ireland. Vol. XLIII. Dublin: Printed for the Institution by John Falconer, 53, Upper Sackville-street.

The Railway Year Book for 1918. London: The Railway Publishing Company, Limited. [Price 5*s.* net.]

Relief from Floods. The Fundamentals of Flood Prevention, Flood Protection and the Means for Determining Proper Remedies. By JOHN A. ALVORD and CHARLES B. BURDICK. London: Hill Publishing Company, Limited. [Price 8*s.* 4*d.*]

Metallurgical Calculations. By JOSEPH W. RICHARDS, A.C., Ph.D. London: Hill Publishing Company, Limited. [Price 5 dols. net.]

A Treatise on the Principles and Practice of Harbour Engineering. By BRYSSON CUNNINGHAM, D.Sc., M.Inst.C.E. Second edition, thoroughly revised throughout and greatly enlarged. London: Charles Griffin and Company, Limited. [Price 25*s.* net.]

The Taylor System in Franklin Management, Application and Results. By Major GEORGE D. BABCOCK, in collaboration with REGINALD TRAUTSCHOLD, M.E., with a foreword by CARL G. BARTH, New York: The Engineering Magazine Company. [Price 3 dols.]

Handbook of Hydraulics for the Solution of Hydraulic Problems. By HORACE WILLIAMS KING. London: Hill Publishing Company, Limited. [Price 12*s.* 6*d.*]

Welfare and Housing. A Practical Record of War-Time Management. By J. E. HULTON. London: Longmans, Green and Co., 39, Paternoster Row. [Price 5*s.* net.]

Scientific Industrial Efficiency. By DWIGHT T. FARNHAM. Chicago: The Brick and Clay Record.

The J. E. Aldred Lectures on Engineering Practice, 1916–17. Baltimore: The John Hopkins Press. [Price 1 dol.]

Gauges at a Glance. By the late THOMAS TAYLOR, Liverpool. Fourth edition. Liverpool: Sim and Coventry; London: E. and F. N. Spon, Limited. [Price 6*s.* net.]

"MECHANICAL WORLD" YEAR BOOK, 1918.—This year book for 1918, the thirty-first year of publication, is issued by the *Mechanical World,* Manchester, and London, 20, Bedford-street, W.C. 2, at the price of 1*s.* net. It contains a large amount of information on steam and the steam engine, the steam turbine, steam boilers, engine parts, bearings, methods of drive, conveyors, elevators, &c., and tables on screw threads, tables of equivalents, and so forth. It is the companion of the "*Mechanical World* Electrical Pocket Book." It has a very complete index.

NEW CONTINENTAL IRON AND STEEL WORKS.

A NUMBER of neutral countries are contemplating or commencing the construction of large new iron works, owing to their unpleasant experiences of shortage of iron and steel during the great war, and it almost seems as if they feared a repetition of this catastrophe within a reasonable period. In any case these new centres of production are bound materially to alter the former export of the international iron trade.

In Sweden a number of important works, at the head of which the Seddeholm company is understood to stand, have decided upon the erection of large iron works in Lapland, a project which has been under discussion for some time. It has been a question of Porjus or Lulea, but recent investigations on the spot point to the latter place as the more favourable. This large undertaking, however, will hardly be taken in hand till the war is over.

In Norway several large schemes in the steel and iron industry are being discussed with much interest, and are likely to be realised in due course. A large capital has been readily subscribed for the Christiania steel works, with a plate rolling mill of large capacity; this concern has purchased five large great factories. On the initiative of General Director Beakstad large iron works are projected at Risör, the production being intended to comprise pig iron, plates and shapes. This scheme is stated to offer several distinct advantages, such as good means of communication, the vicinity of suitable iron ore from the Arendal, the Kragerö, and the Fehn deposits; the transport of the manufactured products will not present any difficulties and finally, 22,000 h.p. have already been secured for the undertaking from the Hogefoss power station with the option of material future increase. The Risör iron works will be laid out for a substantial production so as to reduce the cost of manufacture as much as possible in order to be able to compete against foreign works. Thus the rolling mills are intended for an output of about 100,000 tons per annum, but by an extension of the iron works this figure, it is stated, could be doubled. The start, however, will be on a more modest scale so as to make it possible to commence operations as soon as possible. The third important Norwegian scheme for large iron works will be located in Northern Norway, and to a great extent based upon the use of Lapland iron ore. This project has met with the support of the Chief Board of the Norwegian National Union of Manufacturing Engineers. In the first instance Straumpollen had been selected as a favourable locality, but this place seems to have been abandoned and Narvik chosen instead, the difficulty of obtaining a suitable site at the latter spot having, apparently, been overcome by the assistance of the railway, which owns most of the land in question. The locality chosen is Fagernes, some three kilometres outside the town of Narvik proper, but within the municipal area. One great advantage of Narvik, as compared with Straumpollen, is to be found in the fact that a railway line leads straight from the iron ore quay to the transit quay at Fagernes, and an extra kilometre of railway will make it possible to forward the ore straight to the works without transhipment. A storage quay of one kilometre length will be constructed along the whole of the site of the new works, and the depth of water in such that very little dredging will be necessary. Another important point is that of the requisite power; the Narvik municipality will, it is thought, be able to supply the power needed at the start, some 8,000 h.p., but, with a view to future expansion, a reserve of some 120,000 h.p. must be available. There is, however, a sufficiency of unexploited water power in the vicinity of Narvik, the Sjomen and the Bardofoss falls having been selected in this connection, each of some 80,000 h.p. capacity. With regard to these falls an arrangement must be arrived at with the State. At first the Narvik iron works will, no doubt, principally rely upon the Kirunavaara ore, which is phosphoric, but Norwegian ore will be resorted to later, there being ample iron ore deposits in the neighbourhood.

Ore deposits have recently been found in Narvik itself, and the Kirkenes ore would also be available. Foreign coal mines and iron works have offered co-operation, and with cheap return freight by the ore steamers coal should not be expensive, while Spitzbergen and Bear Island may also be considered in this connection.

In Denmark the erection of steel works on the Frederiksholm land outside Copenhagen is under contemplation by the combine of the Danish iron industries. The project is based on a co-operative principle, the concerns interested undertaking to draw their requirements of steel from the new works. On account of the difficulties offered by the site, the cost will be somewhat heavy, and an aggregate of £800,000 has been mentioned.

The erection of the first iron and steel works and rolling mill in Holland has attracted considerable attention abroad, more especially in Germany, from which country Holland has hitherto received the largest portion of her requirements for shipbuilding and other industries. The Dutch scheme comprises the erection of modern iron works, which will rely mainly upon iron ore from overseas deposits and consequently must be located at tide water. For shipbuilding and structural work there was a demand for steel in 1913–15 amounting to 150,000 tons to 160,000 tons. As regards the supply of ore it is pointed out, that the Rhenish-Westphalian iron industry also to no small extent has to rely upon foreign iron ore for its requirements, and in this respect the Dutch establishment will be more favourably situated than the German works which have to pay an additional freight. Before the war about 8,000,000 tons of foreign iron ore passed Rotterdam annually on the way to the German iron works. As regard coal, this is worked in the Dutch coal mines in the province of Limburg and in sufficient quantities also to supply the new works, which is calculated to require some 300,000 tons of coal per annum. The production of the Emuea mine is estimated at some 500,000 tons annually, and the working of the Hendrick mine is about to commence, and the Mauritz mine is also being proceeded with; all three mines turn out coal suitable for coking. The production of the rolling mill is put at 500,000 tons annually, 100,000 tons to 120,000 tons for the shipbuilding industry, and 200,000 tons to 300,000 tons for other purposes, besides pig iron. The capital of the new undertaking has been fixed at 25,000,000 gulden, divided in 24,500 shares of 1,000 gulden each (80*l.*) and 100 preference shares of 5,000 gulden each. Dutch commerce, shipping and industrial concerns are interested in the new undertaking, amongst them the Dutch Handels Maatshappj, the coal merchants' association, the Nederland Steamer Company, the firm of Wm. H. Müller and Co., the Philips Incandescent Lamp Company, the iron firm of Stork Bros. and Co., the Holland-America Line, the Rotterdamische Lloyd, the Tschwentsche Bank, the Rotterdam Bank Union the Verft Wilton, &c.

PERSONAL.—Messrs. Dudgeon and Gray, Limited, consulting engineers and marine surveyors, 89, Aldgate, London, E. 1, inform us that their directors, Mr. Harry Gray and Mr. T. S. Hunter, have opened offices in the name of Gray and Hunter, Milburn House, Newcastle-on-Tyne, and Gray and Hunter, Merchant's Exchange, Bute Docks, Cardiff, as consulting engineers, naval architects and marine surveyors, and have appointed a staff of resident engineers under the direct supervision of Mr. Gray and Mr. Hunter.

THE RAILWAY YEAR BOOK FOR 1918.—We have received a copy of this year book; it is published at the offices of *The Railway Magazine* at the price of 5*s.* net. It opens with a record of some principal events in railway history, then gives general information on the British railways, rolling-stock, mileage, &c., and reviews each railway separately. The information given includes the names of directors and chief officers, an historical sketch and general data on the service. A map shows the system of each railway company. The book also contains particulars of colonial and foreign railways and a railway officers' "Who's Who."

LOSSES AND NEW BUILDINGS OF THE GERMAN SHIPPING COMPANIES DURING THE WAR.—According to authentic German statistics just published, the German merchant navy, on January 1, 1914, counted 5,459,296 tons; through direct and indirect losses, German shipping concerns have during the war lost about 2,900,000 tons gross register, or more than 50 per cent. of the total. If German vessels now lying in neutral ports are included in the losses the losses then amount to about two-thirds the whole fleet. On the other hand, both the shipping companies and the yards have exerted themselves during the war to make up for these heavy losses by building new vessels, and in this connection the following particulars may be of interest. The Hamburg-America Company has in course of construction the Bismarck, 56,000 tons; the turbine vessel Tirpitz, 32,000 tons; and three more boats of 22,000 tons each, at Hamburg yards. In Bremen, nine steamers are being built, four of which have a carrying capacity of 18,000 tons each. The Flensburg yard is building three large passenger and cargo steamers, and two steamers each of 13,000 tons. The Tecklenborg yard, Geestemünde, is building two cargo steamers of 17,000 tons each, for the Panama Canal traffic. The Hamburg-South America Steamer Company is having built, besides the Cap Polonio, to replace the sunk Cap Trafalgar (18,000 tons) four additional cargo steamers at different yards. The North German Lloyd builds in Stettin two large fast boats, the Columbus and the Hindenburg, each of 35,000 tons, further, the München and the Zeppelin, each of 16,000 tons and 12 more boats of 12,000 tons each. The Africa line has six, the Hansa line 12, and the Kosmos line ten steamers in course of construction, their sizes varying from 9,000 to 13,000 tons. The aggregate of vessels which are being built for the large and medium sized shipping concerns amounts to about 950,000 tons, which, however, will not by a long way make up for the losses experienced during the war, and this is why the State has lent a helping hand through the medium of the measure passed some months ago for the restoration of the German merchant navy.

OUR NATIONAL ENGINEERING WORKS.

NEXT year a balance sheet is to be issued by the Ministry of Munitions of War showing the financial aspect of its productive and trading operations. It will not be an easy task, but it is well that it should be attempted. The Government arranged that instead of the proper accounts, which could not be prepared, a statement should be made in the House of Commons Committee of Supply by Sir L. Worthington Evans, M.P., Financial Secretary to the Ministry. From the official report of his speech we have taken the following items and grouped them in business order. The figures are "round" figures in most cases and must, in fairness, be treated as information given in speech form. Subject to this consideration they throw interesting light, if only in occasional rays, on matters of great interest to engineers.

General statements are to the effect that: The Ministry is the biggest buying, importing, selling, manufacturing and distributing business in the world. It buys and imports raw materials valued at 150,000,000*l.* a year, arranging prices, exclusive supply and transport with the governments of our Dominions and Dependencies. It controls all home coal mines not under the Coal Controller; has taken 58 iron mines over in Lancashire and Cumberland; re-opened lead mines in Wales and opened coprolite deposits in Cambridgeshire. It has also financed extensions of electric power plant owned by private companies, public supply companies and local authorities, the total supply having been nearly doubled during the war. It is preparing a balance sheet of the current year's operations.

The "turn-over," by which is meant the total of sales and inter-department sales, is 2,000,000,000*l.* sterling a year; the "construction sales" amount to 1,500,000,000*l.* sterling a year. The total expenditure is 620,000,000*l.* a year. The stocks in hand at last balancing were valued at 277,000,000*l.* The annual pay roll is 71,000,000*l.* It is evident that these various items are not complete enough to be consistent. A value of 1,500,000,000*l.* sterling could not be produced out of an expenditure of 620,000,000*l.* sterling. Probably some figures represent the Ministry's own transactions and others the total transactions of controlled firms, but there is no explanation of this in the speech.

The criticisms as to mistakes in financial transactions are answered by statements that in the last million payments there were only 20 cases of duplicate payments, and in an earlier 600,000 payments there were 300 duplicates. A special investigation was made and 10,000,000*l.* of overpayments recovered, though probably most of this sum would have been recovered in the usual course.

The capital used by the Ministry gave rise to much question, but the following arrangement of the items mentioned may be taken as the final agreed result.

Fixed Capital.

	£
A. 180 national factories	50,000,000
B. Advances to contractors for buildings and plant ...	35,000,000
Working Capital.	
C. Stock in hand and work in progress	275,000,000
D. Accounts owing by contractors, other Government departments, and foreign and allied governments; *less* owing to contractors ...	75,000,000
Total capital = Assets	435,000,000

Many adjustments would have to be made to find the true capital value. B. is properly lent money from the national point of view, though it has been expended on fixed capital by the borrowers.

180 *National Factories.*

	£
Total capital invested	50,000,000
Total yearly output	300,000,000
Total yearly wages	52,000,000
Total workpeople employed: 281,000.	
Ratio of wages to value of output, 17.33 to 100.	
Average weekly wage per employee, 3*l.* 11*s.* 2*d.*	

It is probable that the capital in this case is all fixed capital and does not include the working capital required to maintain supplies of materials and labour. Materials, coal, local rates, &c. cost 82.77 per cent. of the output. Most of these are engineering factories of the special repetition manufacturing type, devoted to shells, cartridges, guns, salvage repairs, aeroplanes, &c. Some may be shell and cartridge filling factories, chemical works, &c., but no details on this point are given.

METRIC CONVERSION TABLES.—Messrs. The Hoffman Manufacturing Co., Limited., Chelmsford, have now issued a metric conversion table of weights, a copy of which they will be pleased to forward to our readers upon application. This table is a companion to the linear metric conversion table they issued some years ago.

INDUSTRIAL NOTES.

THE report of the committee appointed to advise the Board of Trade on matters arising under the Trading with the Enemy Amendment Act, 1916, affords clear evidence of the extent to which German trade had penetrated into this country. Down to March 19, 1918, the committee dealt with a total of 960 cases, and they recommended the following measures: Businesses to be wound up, or their continuance prohibited, 507. Enemy interests to be vested in the custodian for sale to British subjects, 95. Businesses found not to come within the Act, 95. No recommendation, because businesses were supplying War Departments (since wound up in five cases), 12. No recommendation for special reasons (including 71 cases of friendly aliens), 174. Contracts with enemy subjects or firms cancelled, 58. Contracts not cancelled, 7. Of the remaining 12 cases, in one case consultation with the Foreign Trade Department was recommended; in 10, consideration stands postponed; and in one, an application to cancel a contract was withdrawn. In addition to these 960 cases, others are still being discovered and brought up for the committee's consideration.

The report mentions among the cases dealt with the Siemens business and that of the Badische Dye Company. It adds that the committee have a strong suspicion that in many instances British nationality has been adopted purely as an armour of defence, and it is not at all improbable that the adoption of it has been made a condition of financial support. But such businesses are not, the report states, within the jurisdiction of the Board of Trade. If, however, German trade penetration is to be fully dealt with, some of the cases in which it is carried on by recently naturalised Germans would seem to require consideration. The business of Ettlinger and Co., dealers in ores and metals, is given in the report as a case in point. There are two partners in the firm, Ettlinger, a German naturalised in 1888, and Bernstein, a German naturalised in 1903; the deed of partnership is dated July 1, 1910.

The committee further found that German firms carried on their business in a way to avoid the payment of income-tax in this country and also to strangle British enterprise. The report gives, among other illustrations, the case of a company formed in 1897 to work certain important electrical patents taken out by a British subject, whose relatives held the chief part of the capital, the remainder being held by neutrals interested in working the patents in France. The same patents were worked in Germany by a powerful combination. When the patents expired in 1904, practically the whole of the capital of the English company passed into the hands of the German company under the stress of the German company's competition, and a territorial agreement was made, under which the British company was restricted from selling outside Great Britain, even in British Colonies. The German company, having obtained control of the British company, and sterilised its power of competition out of Great Britain, proceeded to utilise the manufactory of the British company for the purpose of undercutting a very important business of a similar kind carried on by another British company, until it was forced to accept an agreement under which it had to resign foreign business, though it still held on to its business in the Colonies.

Speaking last Saturday on Capital and Labour, before the Liverpool Branch of the Workers' Educational Conference, Lord Leverhulme said that there could be no greater servant of the public and no greater servant of the working man than capital. Men achieved success, he added, by making the most of their opportunities. They talked of the ladder from the board school to the university, but they could not push the student up the ladder if he did not wish to climb, and so far as government was concerned, the Government that gave each of its citizens an equal opportunity could do no more. The functions of capital were often entirely misunderstood. Fortunes were made only by supplying the public better and cheaper than before, and the whole of commercial advantage was built upon service to one's fellows. The working man nowadays aspired to take his share in the management of the industry in which he worked. It was a laudable ambition, and yet it would be most dangerous for the affairs and management of an industry to go into the hands of those who had no practical experience. Thorough training was more important in dealing with business from the financial point of view than from any other aspect.

The master, Lord Leverhulme added, was believed to be an autocrat, with enormous powers given him by his capital, but the only autocrat in the United Kingdom to-day was the working man, who was beginning to act in many ways as all autocracies had acted in the past—to their own undoing. To draw wages on a higher scale was not an end in itself. Money was only a rate of exchange, and real higher wages must be coupled with cheaper production.

Lord Leverhulme further stated that higher production did not mean excessive toil, and he decried the ca' canny policy of trade unions. The whole of the United Kingdom was suffering from it. It had to be paid for by the consumers, and 95 per cent. of the consumers were the working classes. Cheaper production, higher wages, and fewer hours of toil were the ideal solution of the problem of trade unions to find work for their members, and he believed himself the time was ripe for a 6-hour day in industry. Trade unions must get rid of their wrong ideas of capital and labour. Capital was only the tool of the man at the top, and in using that tool he often had a more wretched life than the man working at the lathe or using the hammer or the saw. The only policy to benefit the worker was to reduce the hours of labour.

Mr. G. H. Roberts, Minister of Labour, addressing last Monday the local Labour Advisory Committee, Smethwick, said that the Ministry were dealing with the demobilisation question. They had dealt with 400,000 discharged soldiers, and they were acquiring a knowledge of the particular problems which were associated with the task of resettlement. He was one of those who took part in the voluntary recruiting campaign, and he promised that the State would exercise help when the men returned to civil life to ensure that they were settled as speedily, as smoothly, and as satisfactorily as possible, and he wanted those pledges to be redeemed. They had now got to prove to those men that they were just as much concerned with their future life as they were to place them in the Army to perform those glorious deeds which made one feel proud to be British. There must be a keen desire that the process of demobilisation should be carried through as speedily as possible, but for his part he would prefer to keep the men in the Army even longer than they might themselves feel necessary, in receipt of pay and allowances and the assurance that their wives and children were at least being decently cared for, rather than that they should be released haphazard and returned to swell the ranks of the unemployed.

The general principle which would guide them was to release men proportionately to the industries capable of absorbing them. That had already involved them in a great deal of inquiry. They wanted to have assurance doubly sure that every man on his return should feel that there was a human being taking an active positive interest in his future welfare. They had particulars of every one of the several millions of men who constituted our Army, and they knew that something like 63 per cent. were in the Army with the promise of re-instatement in their original employment when released. Approximately 60 per cent. of the men who had already been released had returned to their old employers, and he was glad to know that the employers everywhere were honourably fulfilling the undertakings they made to the men. He wanted the assurance not only that men were reinstated, but that they were permanently resettled. We should never tolerate the spectacle we had witnessed after previous wars, of scarred warriors at street corners begging for bread and boots. That must never again be a blight on our country.

The Government looked to the Advisory Committees to see that whenever a man felt that he had a grievance it was dealt with, or to advise how it should be dealt with. When demobilisation proper began, added Mr. Roberts, it was going to be a very heavy problem, and they would have to see that it was as limited in duration as possible in order to place the men back into productive work. It was to the interest of the State to get the men back and resettled. The work of the Advisory Committees would be watched with the greatest possible interest.

THE COLOURS OF TEMPERED STEEL.—At the meeting of the Royal Society, held on the 16th inst., a paper was read by Mr. A. Mallock, F.R.S., entitled "Note on Certain Coloured Interference Bands and the Colours of Tempered Steel." After alluding to the interference bands seen when two rows of posts, &c., or two gratings are viewed one through the other, the paper dealt with a particular case of such bands, namely, that when a plate of dispersive material, such as glass, is placed between the two gratings, or, which amounts to the same thing, when a single grating is placed on a thick mirror, and the interference takes place between the grating and its reflective image. The bands so formed are coloured. The composition of the colours in terms of primary red, green and violet is given diagrammatically by means of Maxwell's chromatic triangle for nine examples. It is noticed that the sequence of colours in some of these agrees closely with those of tempered steel. It was shown that the colours of tempered steel are not "colours of thin plates," and it is suggested that they must be due to the formation of some material whose molecular period is comparable to the period of light waves and not to a structure comparable with the wave-length.

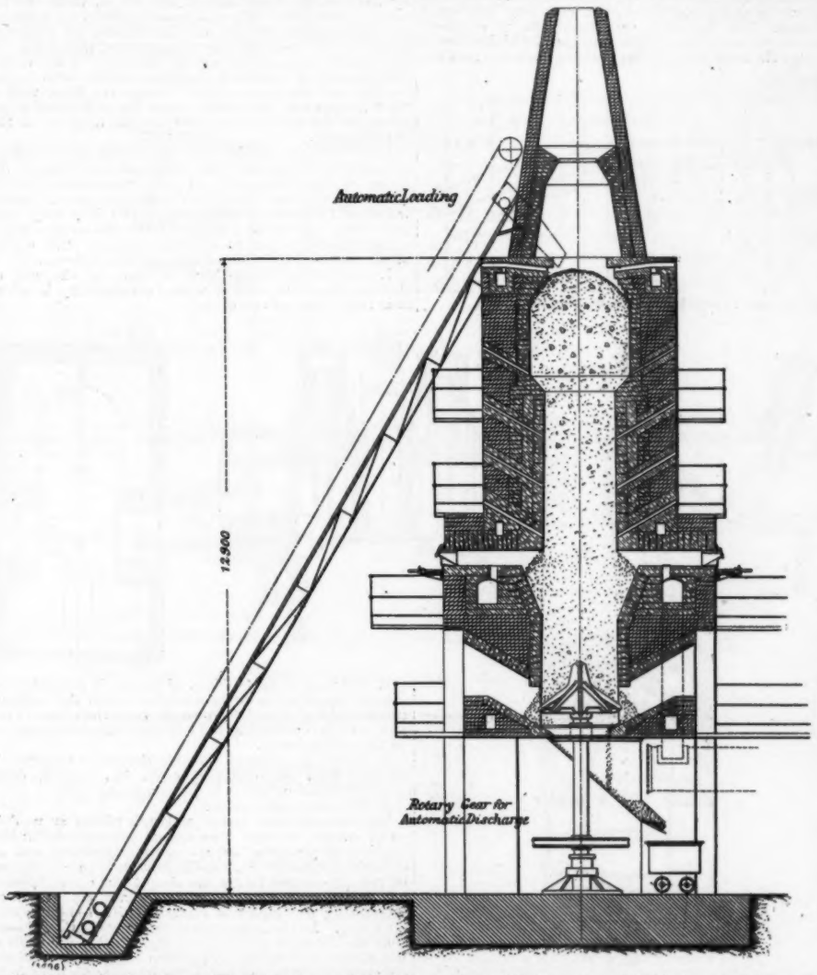
THE DEADBURNING OF MAGNESITE AND DOLOMITE.

*An Advance towards Greater Economy of Fuel and Increased Output in the Deadburning of Magnesite and Dolomite and the Burning of Cement.**

By E. STEIGER.

THIS paper has reference to the "Swiss economic kiln, Steiger's patent," which is claimed to be the best type of kiln extant for the deadburning of magnesite, dolomite, lime and cement. It is clearly the kiln to which Mr. William Donald referred in his recent paper on "Magnesites and Magnesite Bricks." (See ENGINEERING, April 26, page 455.) This particular kiln was worked continuously for two separate periods of six months and twelve months respectively, and was only closed down for want of transport facilities.

Such a kiln consists of one vertical chamber without



contraction at the hot zone. The hottest zone is lined with magnesite bricks, and other parts with best firebricks, the whole having a backing of secondary firebricks. The material is raised by an electric lift and dropped into a charging bell. It gradually descends, passes through the deadburning zone and then through the cooling region, and at the bottom gets automatically pushed out into a locked discharging hopper. The whole process takes about 40 hours, including 3 hours in the deadburning zone.

Air for combustion is supplied by a fan through six damper-controlled openings at the very bottom, and passes upwards through the burned material, becoming very hot by the time it reaches the level of the gas inlets. A secondary system of air flues constructed in the brickwork (which heats the air) conveys air about two-thirds up the kiln and then downwards again to enter through slits just above the gas ports. These flues are only used if the interior supply of air should become irregular. The gas is generated in a producer, and passes through three flues in the brickwork to be heated, and enters the chamber through six ports. With good English coal a temperature of 1,700 deg. is attained, practically steel-furnace heat. The ascending gases finally leave the kiln at 150 deg. C., a suction fan being used to exhaust the gases. The mechanical regulation of the draught and the process of calcination give complete control. The novelty of the kiln under consideration is the rotator at the bottom. It consists of a vertical shaft carrying a conical cast steel head with ribs on upper surface. Its rotation moves the finished material towards the opening, tends to grind any lumps in the calcined product, and also by keeping the column in constant motion causes the material to descend gradually. In general the shaft rotates once in 40 minutes, and wear and tear on the head is not noticeable. The head in the magnesite kiln has never been changed. The automatic and regular working results in an increased output of much better and more uniform material. The actual output was four times as much as from the natural-draught kiln of equal size, and the consumption of fuel per ton of finished material was only about half as much. The power required per kiln is only 30 h.p., nearly half of which is for the working of the fans. The economy of labour becomes very marked as the number of kilns increases.

In a Portland cement kiln, where the temperatures are about 1,350 deg. to 1,450 deg. C., producer gas is not used, coke or coal being mixed with the cement slip. This mixture—the coal or coke being reduced to pea-size—is pressed into briquettes, and so charged into the kiln, instead of charging fuel and cement slip alternately as is customary. This plan is practicable owing to the perfect preheating of the air for combustion, and any kind of coal or coke may be used, even with 30 per cent. of ash, and even lignite and brown coal, whereas hitherto only the best coal would answer for cement kilns. At Nice, a local coal containing 30 per cent. of ash has been in for six months, and less than 4 cwt. of the fuel per ton of the finished clinker was used. Probably 1 ton of best English coal (not dried) would produce 7 tons of clinker, and 1 ton of coke 6 tons of clinker. The kiln at Nice produces 45 tons of clinker daily.

The kiln is similar to the gas kiln described, but without the gas producer, the height and diameter of chamber being greater. The sintering zone is about 7 ft. from the top and 3 ft. in depth, leaving a greater cooling space. The waste gases pass away at 150 deg. C. The clinker is of a spongy nature, easy to grind, and gives a slow-setting cement. Repairs are slight, as there is very little to get out of order. It is claimed that smaller plants of 300 tons a week and upwards can be worked profitably.

* Abstract of a paper read before the Ceramic Society.

ON THE NEW REFRACTORY AND ABRASIVE MATTER CALLED CORINDITE.*

PAR MONSIEUR ALEXANDRE BIGOT, Docteur des Sciences, Consulting Engineer to the Ministry of Armaments and War Material Manufacturers.

IN 1914, a French engineer, Monsieur Noel Lecesne, who died lately from the effects of the absorption of poisonous gas, manufactured by him for national defence purposes, took out a patent for a new process attaining the fusing of bauxite in a very economical manner. In 1916, Monsieur Lecesne filed an application in England for Royal Letters Patent, which was subsequently accorded him.

In the course of the year 1916, Monsieur Lecesne, who was even then very ill, had recourse to me to finish the trials and essays already begun on those products which can be manufactured from bauxite fused by his process. I will here briefly describe my studies and the industrial consequences resulting from them, for the question interests in the highest degree the metallurgic industries of the Allies.

Bauxite, very abundant in the South of France, may be summed in two categories: white and red—but whatever their nature, their fusion is obtained in the same way by the Noel Lecesne process. The composition of French bauxite is varied; it contains on an average 60 per cent. alumina, about 3 per cent. titanic oxide, and 14 per cent. combined water. White bauxite contains a notable quantity of silica and a small quantity of iron oxide; good red bauxite contains from 2 per cent. to 3 per cent. silica, the remainder is iron oxide.

As an example, I give two analyses of bauxite:—

	White Bauxite. Per Cent.	Red Bauxite. Per Cent.
Alumina	59·20	60·10
Combined water	14·10	14·20
Titanic oxide	3·5	3·30
Silica	18·50	2·85
Iron oxide	4·70	21·55

The Lecesne process consists in heating in a cupola oven a mixture of bauxite and anthracite by blowing air into the lower part; before placing the matter in the cupola a fire has been made in the lower part. Under the simultaneous influence of the fire and the combustion gas the bauxite is reduced, aluminium carbide is formed, which, in the presence of surplus air, is transformed almost entirely into alumina; the heat developed by the reaction is such that the mass goes into fusion by successive layers—a special contrivance prevents the matter from adhering to the refractory material composing the sides of the oven. The operation terminated, the mass is cooled by means of the surplus air, and a vesicular fused block is found, in which an immense number of small alumina crystals will be seen disseminated in the solidified mass.

The products obtained have been subjected to analysis after having been freed from the metallic parts by means of a magnet.

	White Bauxite. Fused. Per Cent.	Red Bauxite. Fused. Per Cent.
Alumina	68·80	69·25
Titanic oxide	3·85	3·70
Silica	21·40	3·00
Iron oxide	5·25	23·35
Carbon	0·60	0·50
Loss on ignition	0·10	0·15

This fused bauxite has been designated by the name of "corindite," on account of the crystallised mass of corundum.

White fused bauxite is a very refractory substance. Red fused bauxite resembles emery in its composition it is a powerful abrasive substance.

1.—REFRACTORY PRODUCTS.

Fusing Point.—The point of fusion of the corindite prepared from white bauxite taken from the Var department is very high; a cone made from this corindite begins to melt partially at 1,950 deg. C. It melts at a higher degree than the bauxite which served to make it. This anomaly is explained by the fact that the iron oxide which is found in the corindite has passed almost entirely into the ferrous state and a "spinel" Al_2O_3FeO is formed, resisting a very high temperature.

Binders.—The crushed corindite is mixed with refractory binders, finely pulverised, such as bauxite, kaolinic clay, &c. Binding must be avoided with such bases as lime, magnesia, calcined dolomite, &c. . . . which lower the fusing point of the mixture. The corindite and its binder are suitably moistened and mechanically mixed; the mixture thus treated is employed as an ordinary refractory mixture for the manufacture of firebricks, by hand or by machine. Those made by hand, in a soft paste, show in drying a shrinkage of from 1 per cent. to 2 per cent.; those made by machinery do not shrink in drying.

Baking and Shrinkage.—The dried bricks are baked

* Paper read before the Refractory Materials Section of the Ceramic Society at Sheffield, on May 14.

between 1,350 deg. and 1,400 deg. C.; they undergo no shrinkage. Between 1,700 deg. and 1,730 deg. they lengthen by about 0·5 per cent. Above 1,750 deg. they begin to undergo a shrinkage attaining 3 per cent. at 1,850 deg.

Porosity.—The porosity depends on the mechanical composition of the mixtures and on the compression, it varies from 9 per cent. to 12 per cent.

Resistance to Wear.—This resistance is very great; the product is three and a half times more resisting to wear than good magnesia bricks. A lining to rotary cement kilns made of agglomerated corindite lasts twice as long as a lining made of bricks of non-fused bauxite.

Action of Slag and Scoria.—Refractory products based on fused bauxite are attacked by slag and scoria in the same way as refractory matter made from non-fused bauxite. The action of slag and scoria is being studied and is not yet completed.

It is now ascertained that corindite products possess three essential qualities:—

1. Refractory power very high.
2. Variation of volume almost nil up to 1,750 deg. C.
3. Very great resistance to wear.

Therefore the employment of these products will yield good results in rotary cement kilns, in gas and heavy oils ovens, in coke ovens, &c.

Following on these results an important French Society has been constituted for the working of the French patent; an Italian group has acquired a license for the Italian patent. It would be of the greatest interest for the English refractory products industry to exploit the English patent.

There exist, effectively, in Ireland considerable deposits of white bauxite, relatively poor in alumina and up to the present useless. Fusing trials have been carried out on 500 kg. (½ ton) of this bauxite; the results were the same as with the French bauxite.

Bricks made from this fused Irish bauxite have been tried in England with success. Nevertheless, as Irish bauxite is a little less rich in alumina than French bauxite, its refractory power is a little lower, but remains far superior to that of othor argillaceous refractory matter in England. Fused bauxite is therefore veritably a new product highly refractory; it is a commercial product on account of the abundance of raw material in France and in the United Kingdom, and also because of the cheapness of its manufacture.

2.—ABRASIVES.

Red bauxite, fused by the Lecesne process, furnishes abrasive matter of very good quality. The red bauxite suitable is that employed for the manufacture of pure alumina. Red fused bauxite is of a composition approximating to that of emery. If the analysis given above is compared with that of Naxos emery, it will be found:—

	Fused Red Bauxite. Per Cent.	Naxos Emery. Per Cent.
Alumina	69·25	69·46
Titanic oxide	3·70	—
Silica	3·00	2·41
Iron oxide	23·55	19·08
Carbon	0·50	—
Lime	—	2·81
Combined water	—	5·47

The percentage in alumina is sensibly the same; emery contains combined water, as also lime. Now the presence of lime lowers the fusing point of emery to about 1,600 deg. C., whereas red fused bauxite can be carried to 1,700 deg. without melting. It therefore results that with this corindite ceramic wheels of excellent quality can be manufactured at a temperature of 1,500 deg. C., which is quite impossible with emery, which is too fusible.

Red fused bauxite is not as abrasive as natural or artificial corundum at 90 per cent. to 92 per cent., of alumina, since it only contains 70 per cent. of alumina, but it is superior to emery; it is suitable for the manufacture of special wheels, less hard than those of corundum but which have numerous uses in the metal industry.

NICKEL-CHROME STEELS.—The study of the heating and cooling curves and of the structure of nickel-chrome steels by various authors has given apparently contradictory results. Thus Guillet observed a transformation near 670 deg. C. on heating, none on cooling; Grenet placed the transformation at 700 deg. or 725 deg. C. on heating and at 300 deg. C. on cooling, and Revillon gave the temperature of 745 deg. and 550 deg. C. Experimenting with 13 different steels containing up to 2 per cent. of chromium and 5·5 per cent. of nickel M. Maaloff (*Revue de la Société Russe de Métallurgie*, pages 495 to 515, 1915—the paper has only recently become available) found that the essential point in such researches is the rate of cooling between 550 deg. and 750 deg. C. The rate and maximum temperature of the heating has hardly any influence, provided the rate of cooling be the same. When the cooling rate does not exceed 3·2 deg. C. per minute, the transformation of the Ni–Cr steel is practically the same as that of the corresponding Ni–C steel free from chromium. But when the rate of cooling is raised, the transformation temperature is lowered to 300 deg. C. and lower and becomes indistinct, especially when the Ni and Cr percentages are fairly high. When the rate of cooling comes up to 18 deg. and even 30 deg. C. per minute, there may be no transformation at all, and the structure (generally troostite and pearlite) becomes altogether martensitic. Thus the cooling curve as such has no interest. The effect of the chromium, which renders the steel harder and more uniform, is not to lower the transformation point, but to delay the transformation and to make it dependent on the rate of cooling.

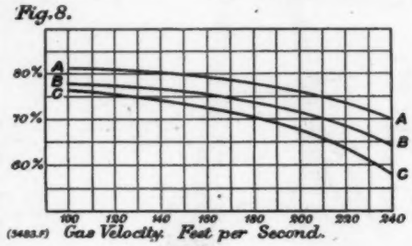
HIGH-SPEED INTERNAL COMBUSTION ENGINES.*

By HARRY R. RICARDO, B.A., Associate Member.

(*Continued from page 590.*)

Volumetric Efficiency.—It is, of course, obvious that to obtain the best results from any type of internal-combustion engine, every effort must be made to obtain the highest possible volumetric efficiency, but at the same time it is also of vital importance that the working fluid shall be in a state of the utmost possible turbulence in order to spread and distribute the ignition. This applies with equal, if not with greater force to Diesel engines in which the necessary intimate contact of the particles of fuel and air is brought about quite as much by the turbulence of the air within the cylinder, as by the spraying of the fuel. In the author's experience, provided that the air in the combustion chamber can be maintained in a state of violent commotion, excellent combustion can be obtained even with very indifferent spraying. The necessary turbulence can be obtained in most cases only by admitting the gas at a high velocity through the inlet valve. The problem therefore resolves

Fig. 8.



itself into one of obtaining the highest possible velocity through the valve with the least possible wire drawing, *i.e.*, the nozzle coefficient of the valve opening regarded as an orifice, must be as high as possible. Provided that the valve and its passages are designed to give the highest orifice coefficient, the author has found that the best all-round results are obtained when the velocity through the inlet valve is in the neighbourhood of 130 ft. per second. With carefully designed valve passages and no further restriction or change of direction after the gases have passed the valve, it is possible with this velocity to obtain a volumetric efficiency within 3 per cent. of the maximum possible figure, while the degree of turbulence is sufficient to give within 2 per cent. or 3 per cent. of the highest possible efficiency, *i.e.*, any lower velocity through the valves results in an appreciable drop in the efficiency and power output due to insufficient turbulence while any higher velocity results in loss of volumetric efficiency due to wire drawing.

Fig. 8 shows a curve based on the average results of a very large number of tests of volumetric efficiency plotted in terms of standard pressure and temperature. It can be proved that if the swept volume of the cylinder is completely filled with working fluid at atmospheric pressure the volumetric efficiency in terms of standard pressure and temperature will be approximately 82·7 per cent. of the swept volume. (See Appendix III.) Three curves are given in the diagram: (A) showing the highest possible efficiency with carefully designed passages and ports and the best possible valve setting; (B) the average of a large number of tests of engines with valves opening direct into the cylinder heads; and (C) the average of a large number of tests with valves in side pockets. In all cases it is assumed that the pipework is short and of large diameter so that it causes very little wire-drawing.

Fig. 9 shows two typical designs of valve port and valve opening:—

1. In a Diesel engine of well-known design, in which, in addition to an abrupt change of direction before passing through the valve, the flow of air is partially restricted after its passage.
2. In a modern high-speed petrol engine.

The freer entry and better stream lining in the case of the petrol engine is self-evident. The design of the exhaust port openings is, of course, of less importance since the bulk of the exhaust is forced out of the cylinder by the positive movement of the piston, while the incoming charge has only the pressure difference between the inside of the cylinder and the outside air to tempt it in. In the design of the exhaust port, therefore, it is well worth while sacrificing the efficiency of the orifice for the sake of providing sufficient cooling both to the seating and the stem, and to design the head with a view to avoiding distortion, hence the difference in the design of the two valves shown in the diagram of the petrol engine.

Piston Design.—If the individual mechanical features of high-speed engines by far the most important is the design of the piston, for not only does piston friction constitute the bulk of all the mechanical losses, but the weight of the piston itself is responsible for a very large part of the load on the bearings and for the stresses in the engine structure due to opposing couples. The design of the piston must be carried out with a view to:—

1. *Dissipating Heat.*—This is met by the use of copper aluminium alloys, whose conductivity is about four times that of cast-iron.

Fig. 9.

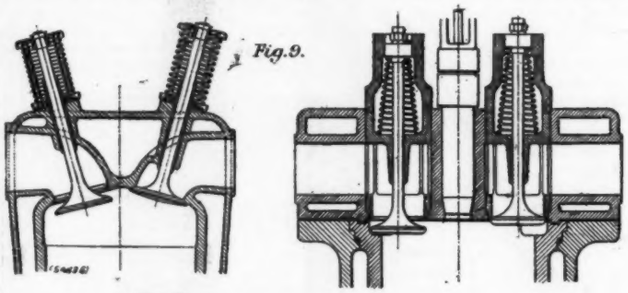


Fig. 10.

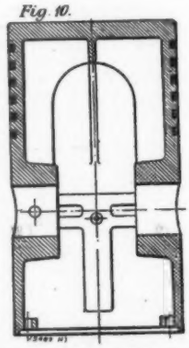
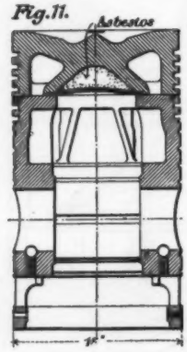


Fig. 11.



2. *Reducing Weight.*—This, of course, is a question of suitable distribution of the material so that the loads are transmitted as directly as possible from the crown of the piston to the connecting rod and from the connecting rod to the cylinder wall.
3. Reducing as far as possible the area of surface in contact with the cylinder walls, *i.e.*, cutting down bearing surface where it is not required.
4. Preventing distortion.

The conventional design of trunk piston as used in most single acting slow-speed internal-combustion engines is probably about as unimaginative and as defective as it could be. In the first place the dissipation of heat is catered for by the simple but unenterprising method of piling on masses of metal instead of by attempting to employ a material with a higher conductivity. In the second place the whole of the pressure from the crown is transmitted through the side walls of the piston and thence to the two extreme ends of the gudgeon pin, with the result that these walls have to be abnormally thick; heavy gudgeon pin bosses must be employed which result in distortion, and finally the deflection of the gudgeon pin sets up a further distortion of the piston and gives rise to trouble with the gudgeon-pin bearing. It is usual also in slow-speed engine practice to make the whole length and circumference of the piston below the piston rings bear against the cylinder walls, though much of this area is useless as bearing surface, and merely serves to increase piston friction. In high-speed engine design, however, every effort is made to reduce the weight and friction, on the one hand by cutting down the weight and bearing surface of the conventional design to the furthest possible limit, and more recently by departing from the more conventional form.

In Fig. 10 is shown a section of what may be described as a conventional gas-engine piston. Fig. 11 shows a conventional Diesel engine piston, Fig. 12 a conventional petrol-engine piston of the same type but in which the weight has been reduced to the extreme limit. Fig. 13 shows a piston much used in high-speed engines and known as the "Zephyr"; this piston was introduced some six years ago, and has proved a marked success. It shows an attempt to depart from convention and clearly has many good points. Fig. 14 shows a cast-iron piston used by the Germans in some of their aero-engines. Fig. 15, another piston used by the Germans, in another type of aero-engine in which the crown and the bosses for the gudgeon pin are stamped in mild steel while the skirt is of cast-iron. Fig. 16 is a steel piston used in some

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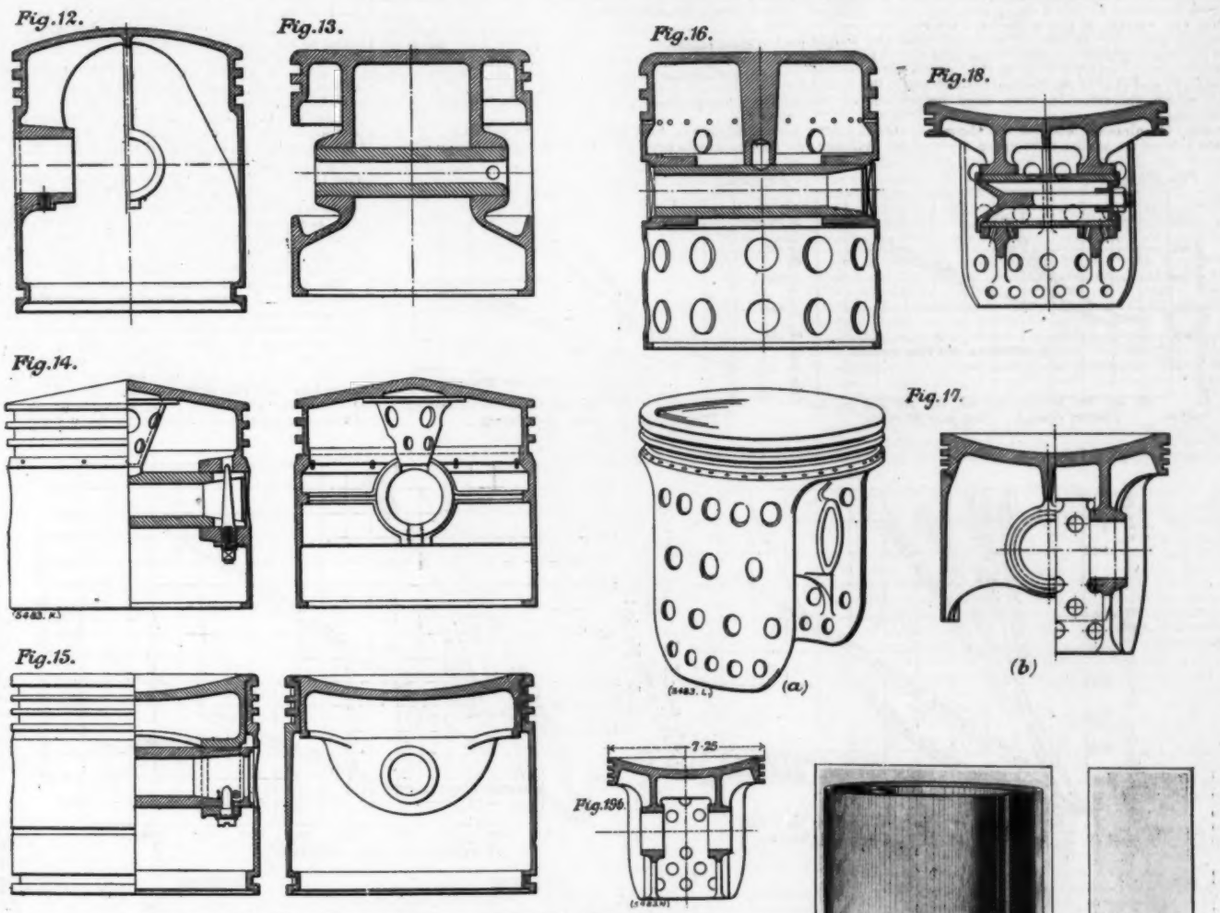
* Paper read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne, on April 30.

DETAILS OF HIGH-SPEED INTERNAL COMBUSTION ENGINES.

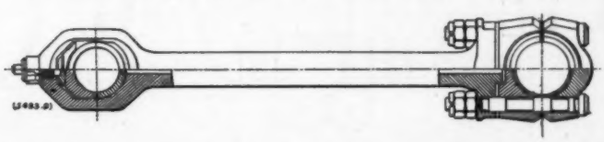


FIGS. 12 TO 19B. VARIOUS TYPES OF PISTONS FOR PETROL ENGINES.

HIGH-SPEED PETROL ENGINE CONNECTING ROD. WEIGHT-10·7 LBS.

Fig.21.

DIESEL ENGINE CONNECTING ROD. WEIGHT-166 LBS.



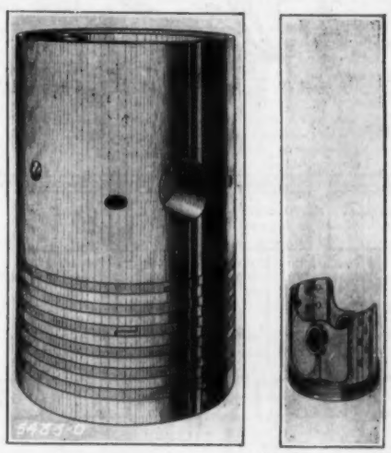


FIG. 20. 80-H.P. GAS AND PETROL ENGINE PISTONS.

early English aero-engines prior to the introduction of aluminium alloy pistons which are now universally employed. Fig. 17 (*a* and *b*) shows a piston designed by the author and made in copper aluminium alloy; this piston has been widely used, and has given very satisfactory results. It will be noticed that among other things the bearing surface is extensively perforated. The object of this perforation is to allow of the free escape of any lubricating oil entrapped between the surfaces, and thus to prevent this oil from being rolled up against the piston rings; such perforation is found to have a very marked effect in reducing both piston friction and oil consumption.

Gudgeon Pins.—In nearly all large internal-combustion engines the gudgeon pin and its bearing are a source of more or less anxiety. In small high-speed engines, however, this pin and its bearings seldom, if ever, give the slightest trouble. The main reasons for trouble in large engines appear to be:—

1. Distortion of the piston.
2. Bending of the gudgeon pin.
3. Severe average loading due to the heavy inertia forces.

Of these by far the most important is the bending of the gudgeon pin due to the fact that the load from the piston crown is delivered to it at its extreme ends, and is taken more or less from the centre. The author has found that by using a very short gudgeon pin and delivering the load to it at points as close to the centre as the connecting rod small end bearing will allow, it is possible to employ a very much smaller bearing surface than usual, and that with considerably less wear than with the conventional long gudgeon pin and very wide connecting-rod bearings. Further, the wear that takes place on the gudgeon pin owing to the small arc through which the connecting rod rocks is very local, and therefore cannot be effectively corrected by rebushing the connecting rod or taking up the bearings. It is obviously very much better to allow the gudgeon pin to float freely so that it rotates both in the piston and the rod, as shown in Fig. 18. In this case the pin rotates continuously, and no local wear takes place, also the gudgeon pin is then carried in bearings throughout its whole length, and although the loading is not reduced thereby the actual rubbing velocity is halved, and the amount of wear is dependent upon the product of the average loading and some function of the rubbing velocity.

Bearing Pressures.—The life and safety of a well-lubricated bearing may be assumed to be dependent upon the average load factor on that bearing, and by load factor is meant, the average load multiplied by some function of the rubbing velocity, for it is this factor which controls the temperature of the bearing, and the viscosity of the lubricant. When dealing with high-speed engines the author employs for comparative purposes a load factor made up of the product of the mean average loading and the rubbing velocity. This factor, however, cannot fairly be used to compare engines of widely different speeds, because it clearly lays too much stress on the rubbing velocity, but it is useful as a comparison as between various high-speed engines. In calculating the load factor, it does not matter in the least in what direction the load is applied, whether it is continuous or frequently reversed, provided always that the lubricant can be constantly maintained and replenished. The maximum pressures since they are applied for so short a time may, in the case of high-speed engines, be ignored provided that they are not sufficient to crush the bearing material or seriously distort the journal. Now in a high-speed engine the bulk of the loading on, say, the connecting rod big-end bearing is due to centrifugal force, and the inertia of the reciprocating mass; the average loading due to fluid pressures is relatively small. Again, the bulk of the loading on most of the crankshaft main bearings is due to centrifugal

pressure set up by the crank-pins, crank-webs, and connecting-rod beg-end bearings. By concentrating attention upon reducing the weight of both the reciprocating and rotating parts the average bearing loadings can be reduced to a remarkable extent, and it is mainly upon the extent to which these parts have been lightened that the success of the high-speed internal-combustion engine depends. It should be noted that the weight of the rotating mass is largely dependent upon that of the reciprocating mass, for it is this which governs the strength and size of the connecting-rod bolts, the bosses for which constitute a very large proportion of the rotating weights.

Fig. 11, already referred to, shows a Diesel piston taken from an engine developing 80 h.p. per cylinder; say, the connecting-rod big-end bearing of a Diesel engine, a gas engine and a high-speed petrol engine, all of about 80 h.p. per cylinder, the Diesel engine running at 250 r.p.m., the gas engine at 200 r.p.m., and the petrol engine at 1,400 r.p.m. The projected area of the crank-pins in the three examples are :—

	Sq. in.
Diesel engine	94·3
Gas engine	45·1
Petrol engine	11·4

The average loading on the crank-pin bearing is made up of :—

1. The actual fluid pressure in the cylinder.
2. The inertia pressure due to the reciprocating masses.

Fig. 22a.

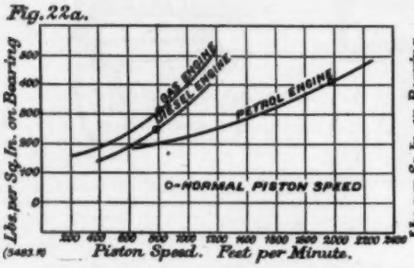


Fig. 22b.

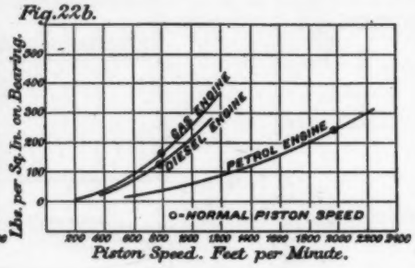


Fig. 23.

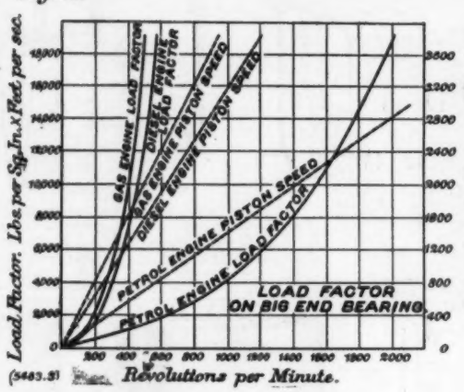
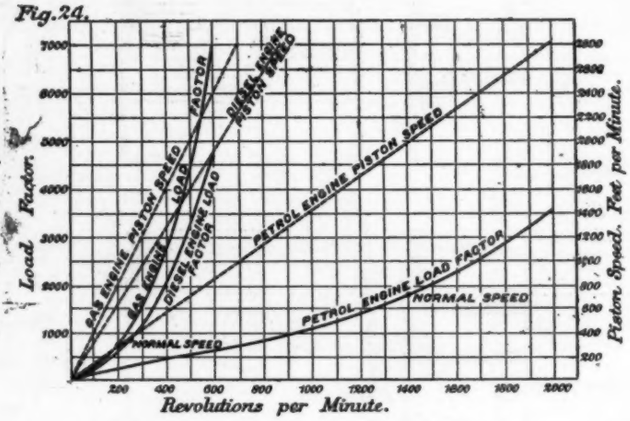

Load Factor. Lbs. per Sq. In. x Feet per sec.
GAS ENGINE LOAD FACTOR
DIESEL ENGINE LOAD FACTOR
GAS ENGINE PISTON SPEED
DIESEL ENGINE PISTON SPEED
PETROL ENGINE PISTON SPEED
PETROL ENGINE LOAD FACTOR
LOAD FACTOR ON BIG END BEARING
Revolutions per Minute.

Fig. 24.



between these two limits. In comparing these load factors it should be noted that the gas engine relies merely on a banjo lubricator, the Diesel engine on forced lubrication of a somewhat restricted form, while the petrol engine is provided with forced lubrication of a much more liberal nature, generally with an oil cooler in series, the quantity of oil passed through the bearings being at the rate of from ½ gallon to 1 gallon of oil per hour per horse-power.

It might be argued that the life and durability of any engine depends upon other parts than the bearings, such for example as the exhaust valves and the valve gear generally. In modern high-speed engines, however, provided that the valve gear is properly designed and that multiple valves are used when either the stresses in the gear or the heat flow become excessive, and provided also that the exhaust valves are seated directly on to watercooled seatings and not, as is sometimes the case, in detachable housings, then trouble with valves is of rare occurrence. Exhaust valves nowadays generally require grinding after about the same numbers of hours running in either high-speed or low-speed engines, and breakages have become things of the past.

The question of balancing and the elimination of vibration is, of course, a vital one, particularly in small high-speed engines, most of which are generally fitted to light structures, such as motor cars and aeroplanes. In such cases it is customary to employ four or more cylinders. With four cylinders and cranks at 180 deg. all the primary forces are balanced and the couples formed by each pair of pistons are opposed to one another so that they exert a bending moment on the structure of the engine but cause no external disturbance. In very

Fig. 26.

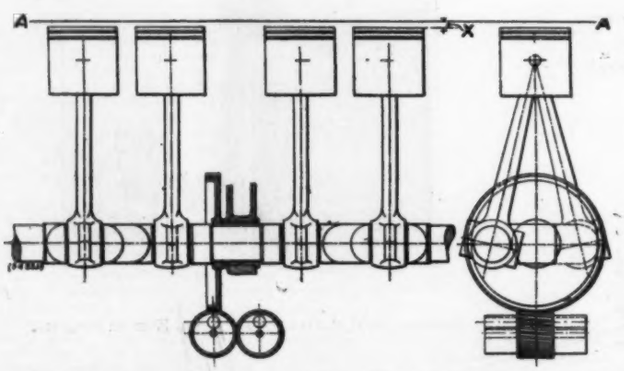
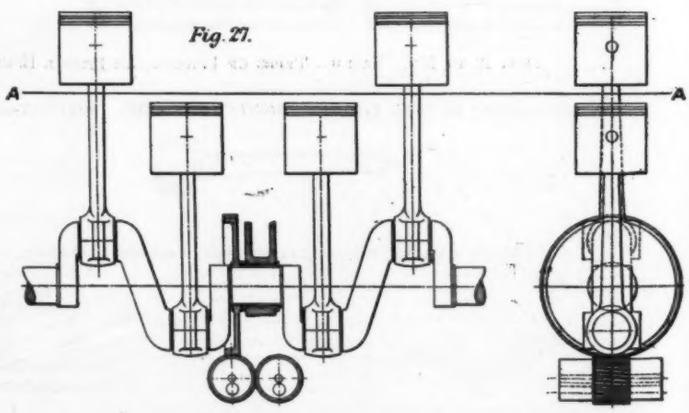


Fig. 27.



and Fig. 19 (*b*) a petrol-engine piston for an engine of the same power, and the same maximum working pressure, but the actual scale is in the proportion of 16 to 7.25. Fig. 20 shows, to the same scale, a piston for a gas engine developing 80 h.p. per cylinder and a piston for a high-speed petrol engine of the same power.

Fig. 21 shows comparative drawings of two connecting rods, one from a gas engine of 30 h.p. per cylinder, and the other from a high-speed engine of the same power. The material of the rod is exactly the same in both cases, and so also is the maximum explosion pressure. It will be seen that the weight of the petrol-engine rod is only 10.7 lb., as compared with 166 lb. for the Diesel-engine rod.

Comparative Wear and Tear of Slow and High-Speed Engines.—In both high and slow-speed engines the general wear and tear may be measured in terms of the bearing wear, for it may be assumed that the life of the other working parts is at least proportional to that of the bearings. Assuming that the system and supply of lubrication is the same in both cases, the wear may be taken as being proportional to the product of the mean average loading on the bearings and some function of the rubbing velocity, probably about the square root. It is interesting, therefore, to compare the average load on,

3. The centrifugal loading due to the weight of the rotating portion of the connecting rod.

These are not all cumulative, but when the necessary corrections have been made, the average loading will be the same when the Diesel engine is running at a piston speed of 1,140 ft. per minute, the gas engine at a piston speed of 1,000 ft. per minute, and the petrol engine at a piston speed of 1,940 ft. per minute (Fig. 22*a*).

It is interesting to note as illustrating the importance of keeping down the reciprocating and rotating weights that in all high-speed engines the wear on the crank-pin is invariably found to occur on the underside, i.e., on the side subjected to inertia and centrifugal pressure, but not to fluid pressure. Fig. 22 (*b*) shows the average loading on the same bearing due to the reciprocating and rotating parts only; as already stated, however, the actual rate of wear does not depend upon the average loading alone, but upon the product of the loading and some function of the rubbing velocity.

Fig. 23 shows the load factor for the three engines calculated on the basis of the mean loading multiplied by the rubbing velocity and Fig. 24, the load factor calculated on the basis of the mean loading multiplied by the square root of the rubbing velocity. The relative wear is probably dependent upon a factor somewhere

high-speed engines it is found that the unbalanced secondary forces due to the angularity of the connecting rods cause a serious disturbance. These also can be balanced by the employment of the "Lanchester" secondary balancer shown in Fig. 25, on page 623. This consists of two rotating balance weights which take the form of unbalanced cylinders revolving in opposite directions in such a manner that the locus of their common centre of gravity travels up and down in a vertical plane, and so balances the displacement of the common centre of gravity of the four pistons which coincide with the centre line when the pistons are on their dead centres, but falls below it at mid-stroke (Fig. 26 and 27). In six-cylinder engines all the primary and secondary forces are balanced, but the two opposing couples formed by each group of three pistons are very large and exert a severe bending moment on the engine structure. This bending moment seldom proves actually destructive, but its periodicity may coincide with the natural periodicity of the structure or some function of it, when severe periodic vibration will occur. This can best be prevented by cutting down the weight of the reciprocating parts to the minimum, and by designing the structure of the engine as stiffly as possible and particularly with a view to resisting bending in a vertical plane.

There is yet another and frequently very troublesome source of vibration in six-cylinder engines, namely, torsional vibration of the crankshaft. This is due to the fact that the end of the shaft furthest from the flywheel is, so to speak, wound up when the maximum turning moment is applied to it and released when the pressure is released. At certain speeds this alternate winding up and release coincides with the natural period of the crankshaft with the result that the shaft vibrates excessively and the reciprocating masses which are attached to it vibrate with it and impart their vibration to the whole structure. Such torsional vibration can be prevented almost entirely by the use of the "Lanchester" damper which consists of a small flywheel mounted loosely on the crankshaft and connected to it through the medium of a friction clutch as shown in Fig. 28. The flywheel rotates at a constant angular velocity, and any relative movement of the end of the crankshaft results in the slipping of the clutch. The damper does not prevent the crankshaft from being wound up and released, but it does effectively prevent it from continuing in a state of vibration. This damper

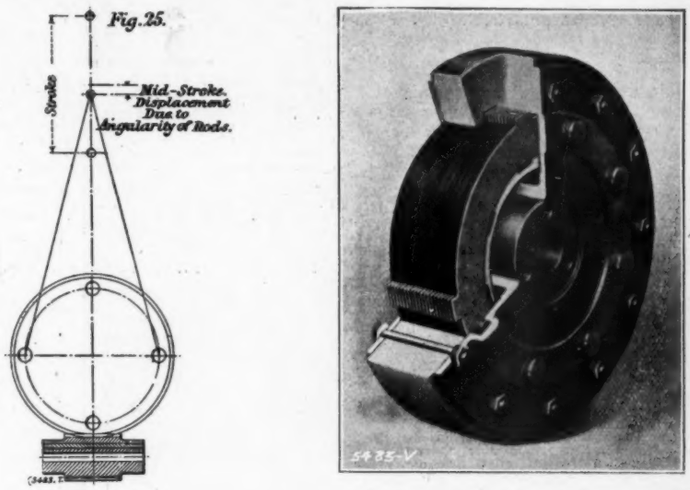


FIG. 28.

has proved most effective on high-speed engines, and one has recently, at the author's advice, been fitted to a large slow-speed six-cylinder Diesel engine which torsional vibration of the crankshaft had proved so troublesome that the engine could not be used. Since fitting the damper this trouble has entirely disappeared, and the engine is now running quite satisfactorily.

In the foregoing remarks the author has endeavoured to show that the modern high-speed internal-combustion engine can compare quite favourably with the heavier slow-speed type as regards durability and relative fuel consumption while its advantages as regards weight and space occupied are, of course, undeniable. There is, however, an impression prevalent that these small high-speed engines required a standard of workmanship, and the use of material that can only be obtained at such a cost as to render them almost as expensive as the heavier slow-speed type. This is certainly not the case. First, as regards workmanship, it is true that a high standard of accuracy is required, and above all the alignment of the engine must be beyond suspicion, but the accurate manufacture of small parts need not be expensive, provided that they are made in large enough quantities, indeed the experience of the last four years has served to show that a high standard of accuracy can be attained commercially without any appreciable increase of cost. With regard to materials, it is not in the least necessary to provide any fancy for costly materials. Crankshafts made from 0·35 carbon steel oil-toughened are found to be perfectly satisfactory. For the valves 3 per cent. or 5 per cent. nickel steel gives excellent results if case-hardened, and for the pistons an alloy consisting of 88 per cent. aluminium and 12 per cent. copper is probably about the best. This alloy has the advantage that it is easily prepared and easily cast, and it is also suitable for die casting. The rest of the engine can be made from the same materials as are employed in the slow-speed type. During the course of the present war the high-speed engine has come into its own, and has developed in a most astonishing manner, the daily output of this country alone exceeding 30,000 h.p.

The author very much regrets that he is unable to give any specific examples of English or Allied engines. The German engines are all remarkable for their excellent workmanship, and also for the fact that although they are built by different private firms in Germany, the design of all of them is evidently controlled by some central authority, for it is interesting to note that all the engines built in any one year have almost exactly the same load factor on the bearings, the same gas velocity through the valves, and the same compression ratio. Each year the load factor and compression ratio are increased, but he increase apparently takes effect simultaneously in all the different types. The German aero-engines as a whole are markedly inferior to ours as regards performance but this is probably to be accounted for by the fact that they have placed rapid production and standardisation of parts before any other consideration.

In conclusion, the author must apologise for having dealt at length with only one feature of mechanical design, namely, the design of piston. Unfortunately, the time available does not permit of dealing with many other almost equally interesting features, such as the design of valve gear and cylinder construction. It is, however, in the design of piston and its influence on other parts of the engine that the essential difference between the high and low-speed engine lies.

It is not suggested that large gas or Diesel engines should immediately be built to run at piston speeds of 2,000 ft. per minute, although this piston speed is now common practice in petrol engines, many of which have to work under the most severe conditions, and without any skilled attention. But the author feels confident that the piston speed of large internal-combustion engines might quite safely be increased to from 1,400 ft. to 1,600 ft. per minute, with the experience now available, and that without affecting adversely either their reliability or durability, provided that designers take advantage of the lessons which have been learnt in the study of high-speed engines.

The author is very much indebted to his colleague, Mr. H. A. Hetherington, who has given most valuable assistance in the preparation of the paper and of all the diagrams, and to Mr. Seaton Scott for the preparation of the lantern slides.

(To be continued.)

HONOURS TO NAVAL ENGINEERS.—The following honours have, with the approval of His Majesty the King, been conferred upon naval engineers, among others: For Services on the Mediterranean Station: To receive the Distinguished Service Cross, Engineer-Lieutenant Peter Harvey, R.N.R. Mentioned in Despatches, Engineer-Commanders L. J. Watson, R.N., and H. H. Ricketts, R.N. For Miscellaneous Services: Mentioned in Despatches, Engineer-Commander H. H. Willmore, R.N. The President of the French Republic has been pleased to confer the "Croix de Guerre" upon the following: Engineer-Commanders E. G. Pallot, R.N., and Bertie Prophet, R.N.R., and Engineer-Lieutenant John Griffith, R.N.R.

CORROSION OF WATER PIPES IN HOUSES.—There having been many complaints about the rapid corrosion of domestic water pipes in Pittsburg, though the conditions do not differ much from those elsewhere probably, the Board of Trade of the municipality decided on an investigation, which was carried out by the A. M. Byers Company of that city. The house-to-house canvas undertaken found little encouragement from the owners of private houses, however, and records were collected in 125 apartment buildings. It was found, of course, that the rusting and corrosion of the pipes in flats varied greatly with the service conditions, size and thickness of pipe, quantity and temperature of the water, &c. It also appeared clear that the corrosion of hot-water pipes decreased gradually with the distance from the boiler, and that the corrosion was more severe in mains and in horizontal lines, both for hot and for cold water, than in vertical lines. More striking, perhaps, considering the importance of the installation and of the treatment of pipes, is the observed similar performance of pipes of the same material, and the noted superiority of genuine wrought iron pipes over soft steel, popularly known as "wrought" pipes; hot-water mains of wrought iron lasted fourteen years, those of steel only seven years. Brass was found superior to the former material, but not sufficiently so to justify the much higher costs of such systems.

CATALOGUES.

Motor Lorry.—The "Karrier" lorry with live axle is illustrated in a folder issued by Messrs. Clayton and Co., Huddersfield, Limited. A plan of the workshops and adjoining streets also appears.

Traction Engines.—Messrs. Clayton and Shuttleworth, Limited, Lincoln, send a small illustrated booklet showing their various workshops and examples of their oil and steam engines in fixed, portable and tractive types, ploughing and threshing machinery and many additions to their usual products.

Machine Shop Accessories.—A large number of useful accessory fittings are illustrated in a catalogue issued by Messrs. James W. Carr and Co., Limited, 35, Queen Victoria-street, E.C. 4. These are chiefly for the machine shop, and sufficient particulars of size, capacity, weight, &c., are stated. Dividing heads, taper milling centres, rotatable milling table, thread milling gear electric grinder, surface plates, vices, &c., are included.

Gas Producers.—The Hughes producer is very well illustrated and described in a catalogue issued by the Wellman-Seaver-Morgan Company, Cleveland, Ohio, U.S.A. In operation the shell is rotated by gearing, and a water-cooled poker is mechanically moved to prevent caking and allow free escape of gas. The coal feed is also mechanically operated, and all the fittings worked out for steady and rapid production with little labour. The figures of results given show a gasification of 3,000 lb. of standard bituminous coal per hour, forming a gas of 168 British thermal units per cubic foot, with a loss in the ash of 1 per cent. of the fuel charged; steam consumption 0·17 lb. per pound of fuel; cooling water 20 gallons per minute; driving power required, 3 h.p.

Grinding Machines.—Messrs. Charles Churchill and Co., Limited, Pendleton, send four catalogues dealing with their grinding machines: Universal, Tool and Cutter, Internal and Piston Ring and Surface types. In all cases sufficient illustrations are given and ample particulars of capacity, horse-power required, suitable grinding wheels, &c. The Universal is capable of external and internal grinding on a great variety of work, including shafts, gauges, cutters, reamers, bushes, saws, &c., and will grind parallel, taper or surface. The speeds for work and table are independent, the gearings for table and feed are entirely enclosed, and a patented gear-box drive is fitted which simplifies the countershafting and gives quick and convenient command of the operations. The Tool and Cutter grinder is the Universal with special equipment for all kinds of cutting tools, including milling cutters. Radial grinding attachments can also be supplied for grinding concave or convex contours. In the Internal type the work is held on a table which provides measured adjustment for positioning to grind two or more holes parallel, such as double cylinders, but the work is fixed while grinding is being done. This involves a running motion for the wheel combined with a planetary motion in addition to the traversing motion. The whole of this complicated movement is worked out with accuracy and security, very fully enclosed and fitted with extremely simple adjustments and controls. The Piston Ring and Surface machine is made with either vertical or horizontal spindle. Grinding machines, of course, appear complicated by comparison with other machine-shop plant. Those who can remember the complications of not having such machines will think them a very simple means of doing complex and difficult work, and doing it quickly and accurately.

War Engineering.—Some of the catalogues and booklets which reach us, and are very welcome, cannot be fully reviewed without indicating the location of what are practically new munitions of war works, though the firms are old-established ones. In the last two or more years a great change has taken place. The State organisation of production was not successful, and the Government turned to the established engineering firms for help. These were fully employed on war work in their accustomed lines. The only way they could meet the Government demands was by erecting new works and laying down new plant on a very large scale, and this they promptly achieved. The demand for ordnance of all kinds and for airplanes, was the most difficult to meet. Shell, grenade, mine, bomb and other ammunition is capable of production on manufacturing lines and the demand was large enough to allow special buildings and plant. The organisation of practically all this work is now under the management of private firms. It may be said that airplane and seaplane production has become efficient as it has passed into private management. The real difficulty is in the organisation and management, far more than in the work itself. In pre-war times most of our large firms were compelled to specialise; but, instead of concentrating on one article, they kept a certain range of work going, and thus maintained their character as engineers rather than manufacturers. The policy was good commercially, as it left them less at the mercy of partial trade depressions. It was also good technically, as it enabled them to maintain staffs of managers, designers and workmen of general experience—men who could take up any branch of engineering with skill and confidence. These trained staffs, who have had little share of public recognition, have been at least an essential and distinct element in meeting war requirements. How adaptable they have proved is shown in one of the booklets referred to where a firm famous for heavy road and farm engines is conducting successfully an immense airplane factory. Many other instances could be given, but it is against the public interest at present to enter into particulars, or to do more than render a vague general acknowledgment of the efforts of these firms.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c. of the Communicators are given in italics.

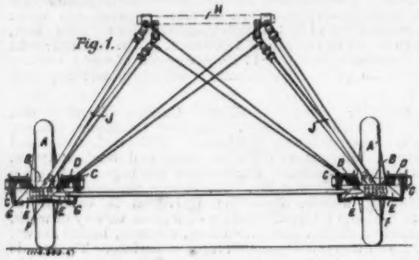
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

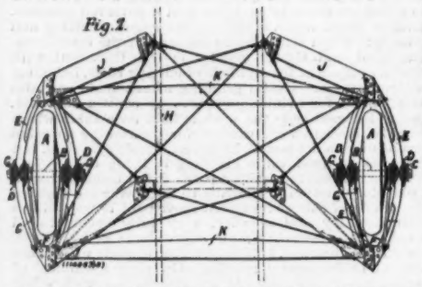
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AERONAUTICS.

114,383. W. E. Chester, London. Aircraft. (3 *Figs.*) August 1, 1917.—This invention relates to landing gear for aircraft. According to this invention, the landing gear consists of two frames secured to the underside of the fuselage, each frame supporting a shaft carrying a landing wheel. The shafts are supported in bearings secured to the frames by shock-absorbing means, such as india-rubber cords, and the bearings are prevented from moving longitudinally by means of tie rods or by vertical guides on the frames. Both ends of the frames

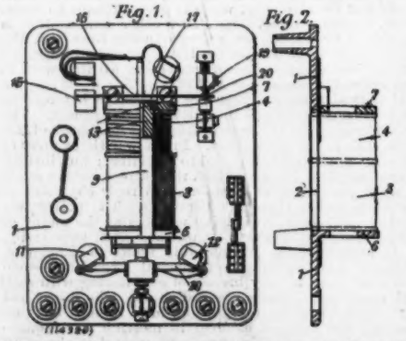




are connected by struts to the fuselage and are held apart by distance pieces. Each landing wheel A turns on a shaft B supported in bearings C secured by india-rubber cords D to a frame consisting of two spars E, held together at each end by sockets F. The bearings C are secured to the front end of the frame by two tie rods G. Each frame is secured to the fuselage H by struts J, and the two frames are held apart at their front and rear ends by distance pieces K. The struts and distance pieces are made of spars of stream-line section, and the parts are tied together by stays. (*Accepted April* 10, 1918.)

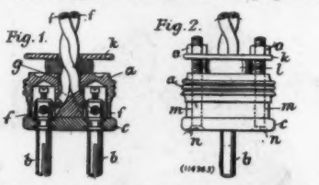
ELECTRICAL APPARATUS.

114,320. The Electric and Ordnance Accessories Company, Limited, and J. Etcheils, Aston, Birmingham. Electro-Magnetic Regulating and Switching Devices. (3 *Figs.*) January 3, 1917.—This invention relates to electro-magnetic regulating and switching devices. According to this invention, the regulating and switching device comprises an electro-magnetic switch of the plunger type, the magnetic circuit



of the operating windings being completed outside the coil or coils through magnetic material and a pole-piece being fixed within the coil or coils, which pole-piece is magnetically insulated from the adjacent magnetic end plate so as to produce an external magnetic field, which acts on an armature forming a vibratory regulator. The regulating switching device comprises a base-plate 1 of magnetic iron having a central rectangular opening 2. The operating coil comprises a shunt winding 3 and a series winding 4, the coil also having a central brass lining tube. A lower end-plate for the coil is formed by a bracket-piece 6 extending from the baseplate 1. An upper end-plate is formed by a bracket-piece 7 fastened to the baseplate 1. The operating coil projects into the opening in the baseplate 1. A plunger 9 carries a contact brush 10 which, when the coil is operatively energised, connects the fixed contacts 11 and 12. A pole-piece 13 is fixed in a non-magnetic ring, which is itself fixed in an opening in the end-plate 7. Mounted on a block 15 is a flat spring 16 having attached to it a disc or annular plate of soft iron 17, which forms an armature. The free end of the spring 16 carries a contact which normally makes contact with an adjustable fixed contact 19. The spring 16 is normally pressed upwards by a spiral spring which is adjustable. The spring 16, armature 17 and contacts form a vibratory regulator. The provision of the non-magnetic ring surrounding the fixed pole-piece 13 permits of the magnetic field of the device extending to the armature of the vibratory regulator. The magnetic field of the operating coil is completed through the baseplate, which is constructed of magnetic iron. (*Accepted April* 10, 1918.)

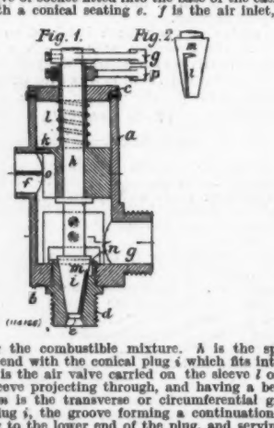
114,363. W. T. Henley's Telegraph Works Company, Limited, London, and W. R. Clements, St. Margarets-on-Thames. Plug Couplings. (3 *Figs.*) May 29, 1917.—This invention relates to electric plug couplings for detachably connecting flexible electric cables to portable electric apparatus or fittings. The invention consists in a coupling comprising a centrally-apertured washer *h* threaded upon the cable *f* beyond the plug body, a ring of compressible elastic material *l* surrounding the cable and interposed between said washer and the plug, and means for drawing the washer towards the plug. *a* is the



usual cylindrical plug body, which is faced, at that end beyond which the split spring terminals *b*, *b*, project, with a plate *c* of insulating material secured to the body *a* by bolts or screws *m*. The flexible cable *f* enters a recess *g* in the plug body *a*, the conductors being led to the binding posts *d*, *d*. The bolts *m*, whereof the heads *n*, *n*, are countersunk in the plate *c*, extend through the body and through holes in the washer *k*, beyond which the threaded ends of the bolts carry nuts *o*, *o*, by tightening which the washer *k* is drawn towards the plate *c* so that the latter is secured to the body *a*. (*Accepted April* 10, 1918.)

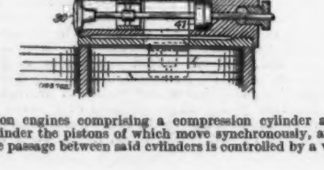
GAS ENGINES, PRODUCERS, HOLDERS, &c.

114,166. R. P. Robinson, Burton-on-Trent. Carburettors. (4 *Figs.*) August 16, 1917.—The invention relates to that class of carburettor wherein two valves for controlling the flow of air and fuel respectively are mounted upon a common axis, and wherein the fuel valve is in the form of a taper plug having in its surface a taper triangular groove so arranged with relation to a passage or recess in the plug seating as to allow the flow of fuel through the said groove to be adjusted, and the air valve in the form of a drum mounted on the same axis as the plug, the object of the invention being to provide an improved appliance of the type referred to, wherein the supply of air and fuel can be easily regulated as required at the moment. *a* indicates the cylindrical casing of the apparatus, which is closed at one end *b* and provided at the other end with a cap *c*. *d* is a sleeve or socket fitted into the base of the casing *a* and provided with a conical seating *e*. *f* is the air inlet, and



g the outlet for the combustible mixture. *h* is the spindle provided at one end with the conical plug *i* which fits into the seating *e*, and *k* is the air valve carried on the sleeve *l* on the spindle *h*, the sleeve projecting through, and having a bearing in, the cap *c*. *m* is the transverse or circumferential groove formed in the plug *i*, the groove forming a continuation of a groove extending to the lower end of the plug, and serving for the flow of the fuel to the groove *m*. In the wall of the socket *d*, adjacent to the groove *m*, is a recess *n* into which the groove opens, but which is of such a length that as the plug *i* is turned the groove will be more or less covered by the solid part of the socket. The drum constituting the air valve *k* has in it a recess *o* which co-operates with the inlet *f*, and is adapted to be adjusted with relation to the valve *i* by means of a lever *p*, an independent lever *q* being applied to the spindle *h* for adjusting the fuel valve *i*. (*Accepted April* 4, 1918.)

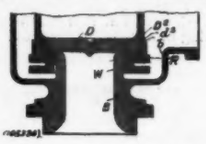
105,752. P. W. Montgomery, Leichhardt, N.S.W., Australia. Two-Stroke Internal-Combustion Engine. (7 *Figs.*) April 18, 1916.—This invention relates to internal-



combustion engines comprising a compression cylinder and a firing cylinder the pistons of which move synchronously, and in which the passage between said cylinders is controlled by a valve. The invention consists in providing in an internal-combustion engine, a controlling valve 30 operating in a ported removable sleeve or casing 39 located in or near as is conveniently possible to the cylinder head (which may be the head of the firing cylinder or a head common to both cylinders if located side by side), said valve being mechanically operated, spring returned, and balanced by a piston 40 operating in said sleeve. The piston 40 is arranged to butt against the end of the casing when the valve 30 is closed on its seat so that the pressure cannot get behind the piston 40 and a state of practical equilibrium exists. Immediately the valve is lifted off its seat the aperture 41 establishes communication between both sides of the piston 40 and the valve 30 may close freely. (*Accepted April* 10, 1918.)

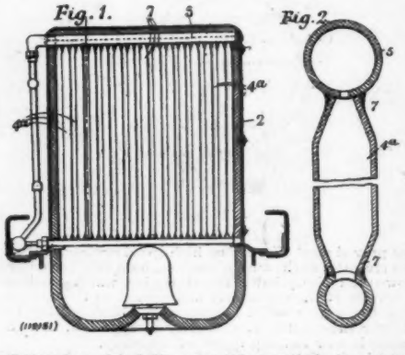
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

105,336. Crosby Steam Gauge and Valve Company, Boston, U.S.A. (*Assignees of G. H. Clark, Melrose Highlands, U.S.A.*). **Safety Valves.** (5 *Figs.*) March 31, 1916.—This invention has for its object the provision of means for adjusting a safety valve both with respect to its "blow down" and "warning." D is the valve disc and B is the base. The valve



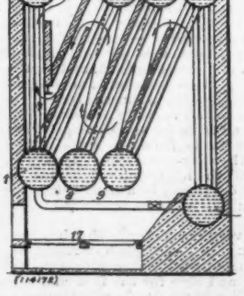
base B is provided with two concentric rings W, R, each adjustably mounted by means of a screw-thread connection. The rings W, R, are so shaped that when screwed up close to the disc surface D^2 they, with the base B, present a surface parallel or coincident with the surface D^2. The surface D^2, curving toward parallelism with the valve axis, terminates at the lip *d*, which lies opposite the lip *b* in ring R. (*Accepted April* 10, 1918.)

110,151. General Engineering Company, Detroit, U.S.A. (*Assignees of A. Doble, Detroit, U.S.A.*). **Steam Generators.** (4 *Figs.*) September 23, 1916.—This invention relates to steam generators and consists in a steam generator comprising a number of separate tubular units which each comprise a plurality of tubes 4*a* having their ends welded to lower and upper headers 5, 7, which extend through one of the side



walls 2 and are detachably connected respectively to an inlet and outlet manifold arranged on the outside of said wall, and is characterised by forming the upper headers 5 of the tubular units of larger diameter than the tubes 4*a* so that the headers can be placed in contact and at the same time serve to space apart the tubes of the adjoining units. (*Accepted April* 10, 1918.)

114,172. F. E. Rainey, London. Water-Tube Boilers. (4 *Figs.*) February 20, 1917.—This invention relates to water-tube boilers of the type provided with a plurality of upper and lower water drums connected by a plurality of angularly-disposed tubes. The invention broadly consists in the provision of a plurality of bottom water drums 1, 8, 9, arranged transversely of and above the fire-bars 17, one behind the other, so as to form an arch over or partly over the grate, and a plurality of top water drums 3, 4, 5, 6, the water spaces of which are unconnected,



such upper and lower drums being connected in series by means of a plurality of straight riser tubes extending the full width of the furnace and by straight downcomer tubes arranged at each end of the drums out of the zone of greatest heat, the arrangement being such as to ensure a positive, continuous and uniform circulation of the water in one direction through both series of drum and tubes, the two series of drums being arranged so that the tubes connecting same are disposed at an angle. (*Accepted April* 4, 1918.